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Annual Report

To the Congress

Fiscal Year 1988

CONGRESS OF THE UNITED STATES
Office of Technology Assessment
Washington, DC 20510-8025

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Contents

Section	*Page*
I. Statements by the Chairman and Vice Chairman of the Board, TAAC Chairman, and the Director of OTA	1
II. Year in Review	9
III. Work in Progress	53
IV. Organization and Operations	55

Appendixes

A. Technology Assessment Advisory Council	65
B. List of Advisors and Panel Members	67
C. Technology Assessment Act	125

Section I.—Statements by the Chairman and Vice Chairman of the Board, TAAC Chairman, and the Director of OTA

CHAIRMAN'S STATEMENT—CONGRESSMAN MORRIS K. UDALL

The maturity of the Office of Technology Assessment is evident to old-timers like myself who were present at the birth of this agency. It shows up in attendance at Board meetings. No less than 8 of the 12 members have been present at every Board meeting I have chaired during the 100th Congress, and all 12 members attended several. This is a remarkable record in an institution where committee hearings are routinely attended by only one or two committee members. Why do the Board members come? They come because OTA is being requested to do work in increasingly sensitive and controversial areas, and the work of the agency is being given heavier weight. Board members wish to ensure that this increasingly important work is carried out correctly.

In this era of legislative branch efforts to hold down the congressional share of Federal Government budgets, OTA has taken its share of a squeeze on real budgets. Sadly, this has happened at a time when congressional demand for OTA's work is growing. We on the Board have been concerned about the growing backlog of requests for OTA analysis and will work with the Director in the coming years to make sure OTA's able staff is directed to the highest priority issues.

This has been a full year for OTA. The staff delivered 41 printed documents, 19 major staff papers and testified 55 times during 1988, most of this in the eight crowded months from February until Congress adjourned in October.

I was especially pleased by OTA's report on *Seismic Verification of Nuclear Testing Treaties* and the report on *Copper: Technology and Competitiveness*. The work on verification resulted in a remarkable convergence and consen-

sus about the extraordinary capabilities of new technology to not only detect but also verify underground nuclear explosives—a key necessity if further progress on nuclear test limitation is to occur.

The copper industry is currently thriving, but in the days ahead must address its present structure if it is going to continue to grow in an era of increasing global competition. The OTA report reminds us of the hard lessons learned in the early 1980s and outlines the steps the industry must take to prevent this cycle from recurring.

VICE CHAIRMAN'S STATEMENT—SENATOR TED STEVENS

OTA's work has received a great deal more attention in the past couple of years, and has drawn praise and criticism from all corners of the political spectrum. Such attention is to be expected if OTA undertakes assessments that are controversial or deal with highly visible subject matter. The trickiest question for the Board has become balancing OTA resources so that technological issues that are not in the mainstream of public debate—but no less important—receive the careful and thorough study that OTA can provide.

Congress should direct OTA to target topics that will come before Congress in which OTA can fill an information void or address issues overlooked by other advisory entities. The Board should resist the temptation of committing the lion's share of our resources to assessments which rehash research already undertaken by the Congressional Research Service, the General Accounting Office, and the numerous think tanks that provide information to Congress on the prominent issues of the day. OTA must delve into the technological issues that would otherwise be overlooked—that is the greatest value offered by the flexibility of the shared-staff concept that led to the creation of the Office of Technology Assessment.

TAAC CHAIRMAN'S STATEMENT—WILLIAM J. PERRY

Technology plays an increasingly critical role in more and more legislative issues of importance to the country. Thus Congress is turning to OTA for assistance in broad and diverse technical fields in order to get a deeper understanding of the technical issues underlying legislation.

While OTA has a broad range of scientists and technologists on its staff, it is a small agency and cannot expect to encompass the depth and experience necessary to deal adequately with all of these issues. OTA deals with this problem in an eclectic way, by reaching out to U.S. industry and universities for the most experienced specialists in the relevant fields to provide OTA with the benefit of their experience in arriving at assessments for the Congress.

As a quality assurance review for this complex process, Congress has established the Technology Assessment Advisory Council (TAAC), a statutory body of 10 senior technologists and businessmen appointed by the Technology Assessment Board, plus the U.S. Comptroller General and the Director of the Congressional Research Service of the Library of Congress. They are selected for their broad, general experience in the management of complex technological enterprises. TAAC's charter is to review OTA's progress in dealing with questions posed by the Congress. They advise OTA on how to improve their performance and give the Congress an independent assessment of the quality of work being done by OTA. This year's review confronted TAAC with some major questions:

- How can OTA's forthcoming study of communication policy issues help the Congress decide whether the time is right for new communications legislation?
- Can OTA's work on the enormous promise of new technology in education help stimulate a hopeful and practical dialog among school boards, school superintendents, State education departments, and Members of Congress about what to do next?
- What are the links among U.S. agricultural practices and global trade, environmental, and population survival

issues? And what should be OTA's role in exploring these links for the benefit of the Congress and the American public?

- How are the arms control options under consideration likely to affect the United States need for defense technology of all types over the coming several decades? What can OTA contribute to framing and addressing this question in a way that integrates across the complexity of the four services and the roles of our many allies?

For example, in reviewing the role of new technology in education, we augmented our group with Dr. Shirley Malcolm, AAAS Office of Opportunities in Science, and Dr. Marshall Smith, Dean, Stanford School of Education. For our review of OTA's defense and space work, we were assisted by David Jones, former Chairman of the Joint Chiefs of Staff, James Woolsey, former Secretary of the Navy, and Guy Stever, Foreign Secretary, National Academy of Engineering.

As a result, we believe that we have greatly increased the assistance provided to OTA, and the confidence with which we assess OTA's work for the Congress. In more detailed reports to the TAB, we reported that OTA's past work in all these subject areas is already distinguished and the work in progress is promising. If Congress continues to provide adequate funding for OTA, the agency has the potential to make a significant future contribution to progress on these issues through unbiased analysis and through explicit attention to bringing their study findings to the attention of significant policymakers.

DIRECTOR'S STATEMENT—JOHN H. GIBBONS

The world has changed a lot in the nine years I've been at OTA. Over 600 million people have been added to the world population—a United States every three years—and almost all the increase has been in the Third World. The United States has changed from the world's largest creditor to the world's largest debtor. Chances for peace seem brighter, while ominous signs of the earth's limits of tolerance for man's activities have appeared. Issues laid before those who govern have become

more complicated, more technical, more controversial, and more insistent.

Advances in scientific understanding and occurrence of unusual "natural" events in 1988 forced mankind to take more serious note of its capacity to change the face of the planet. The deepening stratospheric ozone "hole" in Antarctica, significant ozone depletion at latitudes of human habitat, and global warming combined with widespread drought, hot weather, and major storms warned us that the possible measurable planetary effects of human activities are real. In 1980, OTA began monitoring global warming issues, especially the progress on understanding the underlying science, but congressional concerns at the time required us to devote substantially more attention to air pollution at low altitudes—acid rain, tropospheric ozone, and other bad actors. At the same time, we also gave a lot of attention to the technology of efficient energy use, which is closely linked to both tropospheric air pollution and climate change (as well as other national issues such as our balance-of-payments deficit).

This earlier work on air pollution and energy and our efforts to remain scientifically current prepared us well for the public policy demands of 1988. OTA was able to draw upon a substantial resource of expertise and information not only to respond to immediate congressional inquiries about weather trends and global warming, but also to quickly mount an effort to provide the 101st Congress with some reasoned options to slow down the "greenhouse effect." Health, environment, and industrial competitiveness—all will be affected by the decisions made to address global warming, and OTA will continue to bring relevant information to the Congress.

OTA's assessment of *Seismic Verification of Nuclear Testing Treaties* addressed an issue which has been a subject of contention for roughly 30 years. Research carried out in the last few years has led to substantial improvements in the effectiveness of seismic techniques for detecting underground nuclear explosions and estimating their yield, but the question of the significance of these improvements only intensified the controversy. At the time OTA was asked by the House Foreign Affairs Committee, the House Intelligence Committee, and the

Senate Intelligence Committee to study this issue, they had received sharply conflicting testimony from experts who interpreted the same data in quite different ways. OTA set out to narrow the range of controversy by inviting the experts in the field (including executive branch employees, government contractors, and academics) to address each others' arguments—both in a series of workshops (classified when necessary) and through detailed review and commentary on a series of report drafts prepared by the OTA staff. OTA's final report was able to show that with the exception of a handful of extreme optimists and extreme pessimists, expert opinion on the critical issues is clustered within a manageably narrow range of uncertainty. We were also able to include experimentation which satisfied a wide range of outside reviewers of the technologies involved and the policy significance of both the expert consensus and the remaining controversies. The assessment served as the basis for OTA testimony before both the House Foreign Affairs Committee and the Senate Foreign Relations Committee.

As our nation sought throughout 1988 to strengthen its position in a changing world economy, there emerged a growing consensus on the serious need to keep our educational system on the cutting edge. Evidence that most schools resemble their predecessors of 50 years ago (much more than hospitals, libraries, and business offices) helped focus considerable national attention on OTA's study of new learning technologies and their place in American classrooms. OTA concluded that there was already good news: most children now have access (albeit limited) to computer equipment at school; software has been improving; and most teachers want to use technology to improve learning. At the same time, OTA performed its "early warning" function by pointing to a set of formidable barriers that need to be overcome if these new tools are to have a major effect on education. The priority policy issues are: wider access, problems in the commercial software market, uneven research funding, and the need to increase teachers' readiness to work with new technologies.

During my tenure at OTA the rate of advance in scientific knowledge, and in the technology that new knowledge makes possible, has been especially rapid in several fields. One of these

fields is genetics; in particular, recombinant DNA or the splicing together of genetic material from different organisms. Discovered in the 1970s, advances in recombinant techniques have been extraordinary in the last decade. The potential value of recombinant organisms is now being explored in many industrial sectors. Applications of what many refer to as "genetic engineering" or "biotechnology" range from agriculture to waste treatment. The potential of biotechnology for national competitiveness has been recognized by both developed and less developed nations.

Many important applications of biotechnology require introduction of genetically engineered organisms into the environment if their benefits are to be realized. Food animals that mature more rapidly or produce leaner meat; plants with increased resistance to drought, herbicides, pests, or disease; and microbes engineered to help clean up toxic wastes are just a few of the many such applications that are being developed today. While the potential benefits are obvious, possible negative consequences must also be considered. Of chief concern to the scientific community is the possibility that delicate ecosystem balances may be adversely affected by recombinant organisms.

In May 1988, OTA released *New Developments in Biotechnology: Field-Testing Engineered Organisms: Genetic and Ecological Issues*. The report is a careful review of the kinds of recombinant organisms being developed for use in the environment, and their potential risks, viewed from both genetic and ecological perspectives. The study was several years in the making, involved a large number of outside contractors, and was subjected to an exceptionally high level of external review. Its major conclusion is that, while there are reasons to continue to be cautious, there is no cause for alarm; none of the small-scale field tests proposed or probably within the next several years are likely to result in an environmental problem that would be widespread or difficult to control. We found that adequate review of planned introductions is now possible. Also, in many cases, realistic small-scale field tests are likely to be the only way that potential risks from commercial-scale uses of genetically engineered organisms can be evaluated. I was gratified that OTA's report and a completely

independent publication on the same topic prepared by the National Academy of Sciences reached essentially the same conclusion, even though different approaches were used.

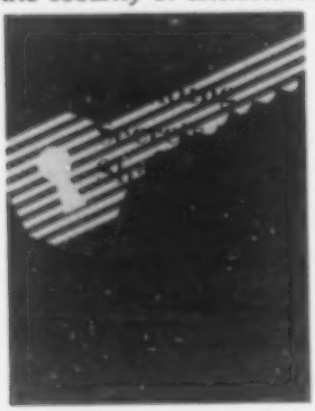
These few examples of analyses that OTA is drawing out for Congress underscore the pervasive impact of technological change on governance. Those who are charged with making policy decisions are dealing with issues of increasing complexity and technical specialization. We seek to help Congress gain access to and utilize information that accurately clarifies issues and provides options, yet does not advocate a particular position or bias. That's a challenging task, but far less difficult than the task of the policymakers—who have to make decisions!

Section II.—Year in Review

The assessments carried out by OTA cover a wide spectrum of major issues that Congress and the country are facing. A brief summary of each report published by the Office during the year* is presented in this section. The reader is cautioned that these are synopses of reports. They do not cover the full range of options considered or all of the findings presented in any individual report.

Defending Secrets, Sharing Data

The influence of defense and intelligence interests on Federal policy for the security of unclassified information in communications and computer systems has become highly controversial. Representatives from U.S. industry, scientific and librarians' associations, civil liberties organizations, and the Department of Defense (DoD), for example, have expressed a number of contrasting concerns for the effects of recent policies on commerce, the free flow of information, and national defense. These concerns point to a need to reexamine Federal policy and its formulation; and they underlie legislation now moving through Congress.



Government at all levels, businesses, and individual citizens have become vitally dependent on the security of electronic communications and computer systems. Government policies have played an important role in determining how privacy and security of data in these systems are achieved and the responsibilities of civilian v. defense-intelligence agencies in achieving them. National security interests are making a noticeable and controversial impact on broader national interests.

Disagreements have arisen as a result of two major trends. One is growing concern for potential access to and misuse of U.S. sensitive, unclassified electronic information by foreign governments and others; the second is the broadening demand for various kinds of information security by the private sector and civilian agencies—demands that generally are unrelated to national security but include common technologies such as encryption and personal identification. The conflicts posed by these trends will become even more intense as information technology continues to spread throughout society and as more valuable information is processed and communicated electronically.

The historical responsibility of DoD for communications security, coupled with the broadened definition of national defense interest, has raised a major policy debate:

To what extent should DoD, particularly the National Security Agency (NSA), be involved in providing the technology and expertise for and in

*Fiscal year 1988 (October 1, 1987 to September 30, 1988).

controlling the use of information security products in the private and civilian government sectors?

Trends in Information Security: Widespread use of communications and computers has increased the need to provide safeguards for electronic data to reduce fraud, embezzlement, and errors; to cut the cost of operations; and to protect proprietary and private data. Security is increasingly important in business, government, and personal affairs, in applications ranging from banking, to auto manufacturing, to wholesale grocery businesses.

Manufacturers and innovators are developing various products and techniques—from cryptographic systems and audit trail software to biometric personal identifiers—to satisfy the needs for safeguards in a market that has yet to stabilize. Innovators in the United States and abroad are developing methods to keep messages confidential, to authenticate messages, and to verify the identities of their senders. The private sector is increasingly developing technological capabilities that did not exist until recently, or were the exclusive province of defense-intelligence agencies.

Defense-Intelligence Interests: NSA has had responsibility for the security of Government-classified communications for decades and, more recently, has been assigned similar responsibility for computer systems. It has become the preeminent source of technical expertise in the United States in cryptography-based safeguards, virtually all of which are classified. NSA also has the mission of collecting foreign signals intelligence, a mission that could be damaged by the dissemination abroad of valuable U.S. safeguard technology.

In recent years, attention has focused on the role of NSA in developing safeguard technology and standards for nondefense use. A civilian agency, the National Bureau of Standards (NBS), has the (legislated) responsibility for developing standards for computer security for civilian agency use. NBS published a widely used national standard for cryptography, the Data Encryption Standard or DES, in 1977. NSA, however, recently announced its intent to provide a secret substitute for DES. This announcement caused concern among U.S. banks and others, partly because of restrictions on the export of the new device and added cost.

DoD announced its intent, in 1986, to take steps to monitor or control access by foreign agencies and others to sensitive, but unclassified information in some U.S. commercial and Federal databanks. Some critics were concerned about prospects for a new level of classification and the effects of restrictions on public access to unclassified information.

The controversy raises many important issues that transcend information security policy, such as the separation of powers between the executive and legislative branches, and the process for balancing different national interests.

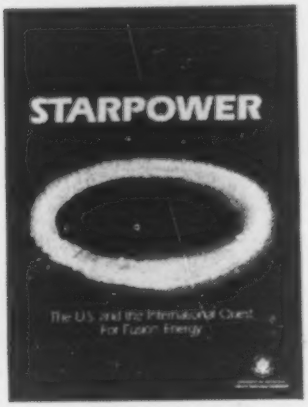
Policy Options: The basic options for policy center around the relative roles of NBS, NSA, and the private sector. Congress could centralize Federal activities for safeguarding unclassified information in Government electronic systems under NSA, continue the current practice of de facto

NSA leadership for communications and computer security, or separate the responsibilities of NSA and NBS for the development of safeguard standards along defense and nondefense lines. The latter option is essentially that of HR 145 (the Computer Security Act of 1987), which passed the House in mid-1987.

Each option has shortcomings. Essentially, the choice depends on whether policymakers prefer to tolerate greater tensions, a blurred division between defense-intelligence and civilian matters, and more constrained private sector technical capabilities, or to accept risks that intelligence capabilities might be compromised by the proliferation abroad of U.S. safeguard technology.

Starpower: The U.S. and the International Quest for Fusion Energy

Fusion energy could be an attractive source of electricity because it has potential environmental and safety advantages over other major energy sources and has an essentially unlimited supply of fuel. However, it is too early to tell whether fusion energy can be economically produced.



Even if successfully developed, fusion will probably not provide a significant fraction of the U.S. electricity supply before the middle of the 21st century. Although fusion researchers have made a great deal of progress in the last three decades, at least three more decades of research and development will be required before a prototype commercial reactor could be operated and evaluated. Fusion's widespread use would take several decades beyond that.

The near-term goal of the U.S. Department of Energy's (DOE) magnetic confinement fusion program is to complete the research and development needed to design such a prototype fusion reactor by the early part of the next century. However, the U.S. fusion budget currently falls far short of what is needed to meet that goal independently.

DOE's schedule requires either substantially increased U.S. budgets or an unprecedented level of collaboration between the United States and other major work fusion programs—those of Japan, Western Europe, and the Soviet Union.

Fusion research has a long history of successful and mutually beneficial international cooperation. If this tradition can extend to a much greater level, the countries with major fusion programs can share much of the cost of developing fusion power. Large-scale collaboration between the United States and foreign partners will require sustained support at the highest levels of government and the resolution of a variety of potential difficulties.

International collaboration cannot substitute for a strong U.S. research program. Sacrificing the domestic program to support international projects

would undermine the reason for collaboration and compromise the ability to conduct it successfully.

Potential problems with fossil fuels and nuclear fission provide incentives to develop alternate energy technologies. Unlike fossil fuel powerplants, fusion reactors would not produce various air pollutants, nor would they produce carbon dioxide gas, whose accumulation in the atmosphere would affect world climate. Unlike nuclear fission—the process used in existing nuclear powerplants—fusion should not produce high-level, long-lived radioactive wastes. Also, the safety of an appropriately designed fusion reactor should be easier to demonstrate than that of a fission reactor.

However, both coal and nuclear fission have fuel supplies adequate to provide energy well into the next century and beyond. The prospect of future energy shortages alone does not justify a crash program to develop fusion power. Therefore, fusion will not be commercially used unless it is clearly better. It would be unwise to emphasize one fusion feature—environmental or safety advantages or economics—over the others before we know which aspect will be most important for fusion's eventual acceptance.

After growing more than tenfold in the 1970s, the U.S. fusion program budget has been declining in recent years. Including the effects of inflation, present funding is about one-half of its peak level of a decade ago. Cuts in the program budget have not resulted from poor technical performance or pessimistic evaluations of fusion's prospects. Rather, a much-reduced sense of public urgency, coupled with the mounting Federal budget deficit, has tightened the pressure on fusion research budgets.

Choices made over the next several years can place the U.S. foreign program on one of four fundamentally different paths:

1. With substantial funding increases, the U.S. fusion program could complete its presently mapped-out research effort independently, permitting decisions to be made early in the next century concerning fusion's potential for commercialzation.

2. At only moderate increases in U.S. funding levels, the same results as above might be attainable—although possibly somewhat delayed—if the United States can work with some other major fusion programs at an unprecedented level of collaboration.

3. Decreased funding levels, or current levels in the absence of extensive collaboration, would require modification of the program's goal and delay U.S. evaluation of fusion as an energy technology.

4. Eliminating funding for fusion research in the United States would foreclose the possibility of developing fusion as an energy technology domestically. Work would probably continue abroad, although possibly at a reduced pace. Resumption of research in the United States at a later date would be possible but difficult.

Healthy Children: Investing in the Future

Despite many gains, the United States could do better in preventing health problems in infants and young children. The Nation ranks 17th among industrialized countries in infant mortality—a position that has not improved since 1980. A significant number of young American children have not received all their recommended immunizations. Furthermore, low-income children bear more than their share of the burdens of illness and death. In 1986, between 14 and 19 percent of all children under age 13 had no health insurance coverage; 61 percent of these uninsured children were from poor or near-poor families.

OTA identified seven strategies for improving American children's health through prevention or improved access to medical care:

1. *Improving access to early prenatal care for poor women*—The high U.S. infant mortality rate is due largely to the high incidence of low birthweight births (less than 5 pounds, 8 ounces) in this country. Early or augmented prenatal care can reduce the low birthweight problem, especially in high-risk groups such as poor women and teenagers. Every low birthweight birth avoided by prenatal care saves the U.S. health care system between $14,000 and $30,000 in initial hospitalization and long-term costs. If eligibility for Medicaid were extended to all pregnant poor women, health care savings from preventing low birthweight would outweigh the $4 million national cost of extra prenatal care among newly eligible women.

2. *Encouraging appropriate well-child care*—Adherence to the schedule of well-child care visits required for complete immunization of young children (seven visits in the first 6 years of life) is not only effective but also cost-saving to the health care system. Whether more well-child care visits in the first 6 years of life than the seven visits required for complete immunization would be cost-effective is unknown, because other components of well-child care have not been found to be effective in the evaluations that have been completed to date.

Over 20 percent of all 2-year-olds in the United States were not fully immunized against measles in 1985. To encourage the use of appropriate well-child care among poor children, the Federal Government could encourage States to increase Medicaid fees paid to physicians for Early and Periodic Screening, Diagnosis, and Treatment (EPSDT) screening visits on the immunization schedule.

3. *Encouraging the use of child safety restraints in automobiles*—Accidental injuries are the leading cause of death in U.S. children after the first few months of life, and about 15 percent of all children who die from accidents are passengers in motor vehicles. State laws requiring the use of child safety restraints in automobiles have indisputably reduced deaths and

serious injuries in very young children and are probably cost-saving to the U.S. health care system.

All States currently have laws requiring the use of infant or child restraints, but some laws are more rigorous than others. For example, 38 States have no restraint requirements for children over age 5, and many States do not require restraints for children over 3 or 4. To encourage States to adopt effective laws, the Federal Government could promulgate a model child safety restraint law and require States seeking Federal highway funds to enact it.

4. *Improving poor children's access to physicians' care*—The frequency with which American children see a physician when they are sick depends very much on family income and eligibility for health insurance. The higher the family income, or the more generous the health insurance coverage, the more services a child uses. Parents do not discriminate well between illnesses for which medical care is highly effective and those for which it is not. When parents take their children to a doctor less frequently for financial reasons, they tend to reduce effective as well as ineffective or marginal care. To increase poor children's access to effective care, Congress could require that eligibility for Medicaid be extended to all children through 8 years of age in families with incomes below the Federal poverty level. Congress could also increase access to physicians' services for Medicaid-eligible children by requiring States to reduce the growing disparity between Medicaid and private fees for physicians' services to children.

5. *Expanding newborn screening to include tests for additional disorders*—All 50 States and the District of Columbia screen and treat newborns for phenylketonuria (PKU) and congenital hypothyroidism (CH), disorders that lead to severe health problems and even death if not detected and treated in the first few days or weeks after birth. An analysis of the incremental costs and effectiveness of six expanded screening strategies beyond the two tests found one strategy—screening for PKU, maple syrup urine disease, and galactosemia using a single blood specimen—that would annually save an additional 68 affected infants nationwide at a net health cost care per case detected and treated of between $85,000 and $277,000, a cost range that is in line with investments currently made for other medical technologies.

New tests are now available to screen for sickle cell anemia, cystic fibrosis, biotinidase deficiency, and congenital adrenal hyperplasia. Newborn screening and early treatment for sickle cell anemia is clearly effective in saving the lives of some affected babies, but information is still lacking for estimating its cost-effectiveness or the effectiveness of screening for the other disorders. To better determine if such tests can be cost-effective, the Federal Government could increase funding for research on such newly developed tests.

Two other strategies for improving children's health that are promising but need further study are:

6. *Encouraging the development of comprehensive school-based clinics for adolescents at risk of unwanted pregnancy; and*

7. *Encouraging the development of nurse home-visitor programs for pregnant women and infants in families at high risk of low birthweight births or child maltreatment.*

Mapping Our Genes—Genome Projects: How Big? How Fast?

A genome is the total DNA in each cell of an organism. The genome contains the genetic blueprint for the organism's form and function.

Genome projects use techniques of molecular genetics to map the structure of all or part of an organism's genome. The goal of genome projects is to collect information systematically about the genetics of entire organisms and to develop new technologies for doing so. Genome projects would lay a foundation for human genetics research in the 21st century. They include several components:

- improvement of genetic databases and linkage among them;
- genetic linkage maps—sets of markers on chromosomes to locate genes of interest for further study;
- ordered sets of stored DNA segments that cover large expanses of chromosomes;
- new technologies to handle, detect, clone, sequence, and purify DNA;
- pilot projects to determine the sequence of DNA in chromosomes or large regions of chromosomes; and
- new computer software and hardware for analysis of genetic map and sequence information.

The principal justifications for genome projects are scientific, although technological spinoff will also result. Genome projects will produce, for example, genetic tests for human diseases, instruments widely useful in biotechnology, and information to develop pharmaceuticals based on knowledge of human genes.

The National Institutes of Health (NIH) and the U.S. Department of Energy (DOE) have special genome programs. NIH's projects, projected at $28 million for 1989, will develop new methods to study the genetics of complex organisms and new tools to analyze resulting data: biological methods, computational methods, and other resources. DOE proposes, in its 1989 budget request for $18 million, to generate sets of DNA representing human chromosomes, to develop methods for computer analysis of genetic data, and to devise instruments for molecular genetics.

NIH funds the largest fraction of genetics research, a large majority of genetics researchers, and most of the relevant research infrastructure. DOE develops instruments, manages large-scale projects, has extensive com-

puter expertise, houses the DNA sequence database, and funds the national laboratories. DOE was the first agency to commit its resources to genome projects explicitly. The National Science Foundation (NSF) is developing several biology centers nationwide, has genetics and instrumentation grant programs comparable in size to DOE's, and has a legislative mandate to coordinate science among Federal agencies. Each agency thus has a distinct contribution to make to genome projects. Attempts to consolidate authority at a single agency might simplify some management problems, but the difficulty of choosing which agency might delay work, threaten the aggregate budget, and would not solve problems of coordination with foreign and private sector efforts. An alternative option is an interagency working group composed of academic scientists, government agency representatives, industrial scientists, and other experts.

Are Genome Projects Big Science?

Genome projects would be larger and more directed than most research in biology, but small in scale compared to high-energy physics projects and space programs. Genome projects will require sustained commitments of substantial resources, with more central coordination than is usual in genetics research. A DOE advisory committee and a committee of the National Academy of Sciences have recommended annual budgets of $200 million per year for genome projects. Genome projects would be directly linked to ongoing research in genetics and would produce useful results long before they were completed. New facilities dedicated to genetic mapping and sequencing may or may not prove necessary; technologies yet to be developed will determine the need for such facilities.

Are Genome Projects Important?

The importance of databases, computer analysis, new technology development, and various types of gene maps is undisputed. These have been called "high-priority normal science," because they address critical research needs and promise to make research more efficient by doing once systematically what would otherwise be done piecemeal. The value of massive sequencing remains in dispute and can be resolved only by pilot projects.

Gene maps and DNA sequence data will be most useful if the entire research community has access to them. This will require special planning by Federal research agencies. Policies of Federal agencies can also affect the rate and magnitude of commercial application. Patent policies of NIH, DOE, and NSF can expedite commercialization of products resulting from federally funded research.

Do Genome Projects Raise Ethical Questions?

Yes, but only indirectly in most cases. The fundamental issues are not new, but emerging genetic technologies will make them salient. Genetic techniques will as a rule permit detection or prediction of disease long before treatments are available, so a gap will arise between diagnosis and therapy.

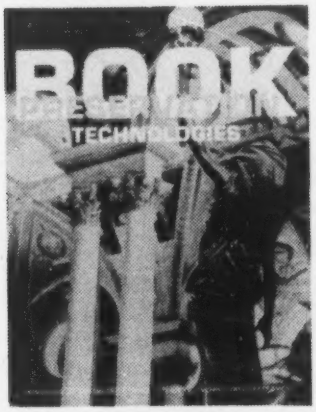
Availability of diagnostic technologies may also intensify the debate about prenatal genetic testing and abortion. Information about human genetics will influence theories about human origins and the relationship of genetic factors to socially desirable (or undesirable) traits. Genetic information has often been used for political purposes in the past; information arising in genome projects could be similarly misused. These are not arguments against research efforts, however. Policies to address such issues can focus on uses, rather than the data and technologies themselves.

International Efforts

Several European governments support genetics research, but none has explicit genome programs except Italy, which has begun a few pilot projects. A privately funded effort will soon begin in the United Kingdom. Japanese government actions have been modest to date, but concern persists that Japan will seize the technological lead from America's advantage in basic genetics. There will likely be international competition to develop new technologies, but new information gained from genome projects will benefit all nations. International cooperation can build on the successes of existing collaborative arrangements among databases and scientific groups.

Book Preservation Technologies

Even in today's high tech society, books are the principal records of human civilization. Over the centuries, books have become the most reliable and permanent records available, but, in the last century, that reliability has been threatened by the use of "modern" acidic paper, which becomes brittle and unusable in a relatively short time. Books printed since the mid-1800s are deteriorating en masse in libraries the world over.



The U.S. Library of Congress initiated a major preservation program in the early 1970s and developed a mass deacidification process that is now being tested at a pilot plant. Planning is underway to design and construct a full-scale facility that could treat 1 million books per year.

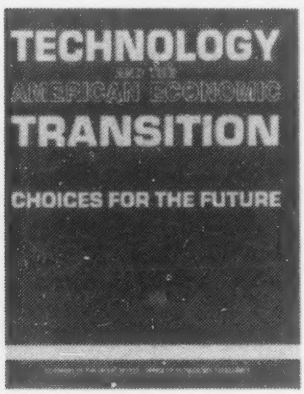
The Library's process is unique and effective but also presents some new engineering and safety concerns because it makes use of a highly reactive chemical—diethylzinc—as the deacidification agent. OTA's technical review of this program indicates a high potential for success in meeting the Library's stated goals. However, the program is still in the developmental stage with difficult and complex tasks ahead. Despite the credible pilot plant program currently underway, additional work is needed to determine accurate costs for a full-scale plant and how such a plant will be managed. Also, the apparent competition among several firms and institutions for the best deacidification process would make continued evaluation of the relative

costs and effectiveness of alternate deacidification processes prudent. OTA's findings include:

- The diethylzinc (DEZ) mass deacidification process developed by the Library of Congress produces effective and uniform paper deacidification, and leaves an adequate alkaline reserve on treated book papers.
- While substantial life extension benefits of DEZ mass deacidification are generally accepted, more quantitative testing is needed to determine specific benefits to the Library's collection.
- The DEZ deacidification system can be safely operated but some hazards are inherent in that process and risks will always be present. Safety practices will always require careful, consistent top management attention.
- Of those processes for which OTA had sufficient data, no other mass deacidification system meets as many of the Library's criteria for ease and effectiveness as does the DEZ process, but two alternatives merit some consideration (Wei T'o and Bookkeeper). The effectiveness and other aspects of these alternatives must be more carefully checked if they are considered, but present indications are that these alternatives could be lower cost than the DEZ process.

Technology and the American Economic Transition: Choices for the Future

The American economy has entered a period of fundamental change. During the next two decades, new technologies, rapid increases in foreign trade, and the changing tastes and values of Americans are likely to reshape virtually every product, every service, and every job in the United States. These forces will shake the foundations of the most secure American businesses.



Eight congressional committees asked the Office of Technology Assessment to take a broad look at the opportunities and risks created by the new environment. OTA's response describes the economy as a set of complex networks that convert the skills and savings of Americans into amenities like health, food, education, and recreation. It also develops a set of specific hypotheses about the way economic networks could operate in the future. The analysis makes no attempt to forecast the future. Instead, it attempts to provide the clearest possible description of the available choices and their implications. It measures progress both in terms of income growth, the quality of amenities, and the number and quality of jobs.

The networks emerging in the economy are likely to be relatively decentralized and able to deliver products and services tailored to comparatively small, fast moving markets. Imported products will be used throughout

the economy. The economic networks are also likely to be less dependent on natural resources and much more dependent on the intellectual and interpersonal skills of people. They are likely to depend critically on the ability of the Nation's educational system to produce people with versatile skills, and to maintain and upgrade these skills.

The study identifies many of the changes that have already occurred because of this ongoing economic transition. The number of lawyers, scientists, and data-entry clerks needed to supply Americans with food, for example, is now roughly equal to the number of farmers. The mix of purchased goods and services, as well as unpaid personal time, used by Americans to achieve recreation, health, and other amenities has also changed. Most of the new jobs created in the last several years have been in managerial, professional, sales, and technical occupations.

In addition, there has been considerable growth in the purchase of services by American businesses and households. Services once provided at home by household members, such as care of children and the elderly, are now purchased. Decline of free time, especially by women as they continue to enter the work force, has also meant, for example, that more meals are eaten outside the home. At the same time, some services once purchased, such as movies, can now be provided at home (through VCRs). These and other shifts in consumption, production, and employment patterns will continue and perhaps accelerate as changing technology, trade and tastes further influence the shape of the future economic networks.

The changes before us offer unprecedented opportunities for growth, but they also contain the seeds of potential stagnation and decline. It is not clear, for example, whether the majority of Americans will be able to find attractive opportunities for work, or whether only a credentialed elite will enjoy such opportunities. Failure to take advantage of emerging technologies and to grasp the new rules of international trade could leave America bypassed by nations that have discovered better ways to profit from innovation.

While fundamental change is underway, few features of the change are inevitable. The Nation's future has probably never been less constrained by the cost of energy or materials or the limits of human strength, dexterity, or memory. Much less depends on physical limits to what can be done and much more on what Americans choose to do.

One of the most critical issues is whether the flexibility and dynamism essential to progress in the emerging economy will come at the expense of individuals, or whether individuals themselves will become more flexible because of continuous opportunity for learning and growth. In the past it seemed necessary to make a Faustian compact with technology: efficiency could be improved only by sacrificing individuality. Efficiency demanded mass production of uniform products, and a reasonable income often required acceptance of a constraining and narrowly defined occupation. Emerging technology may make it possible to avoid making such choices.

Can America operate a dynamic and growing economy and navigate a transition to a new, more flexible, economic structure without falling into

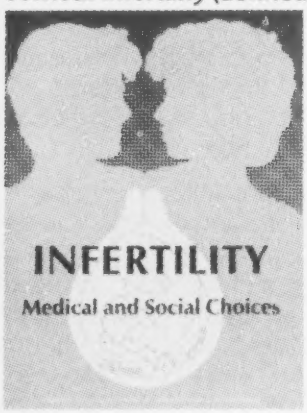
any potential traps? Specifically, can the nation develop a set of marketplace rules that bring private and public goals into greater harmony without stifling the innovation and entrepreneurship needed to reach these goals? Can both workers and investors be given sufficient incentives to undertake major changes in production systems? Can a major transformation be managed so that unavoidable trauma will not uniformly be borne by a single group?

The assessment argues that the answer to all these questions is yes—but only given an unflinching reexamination of some of the most cherished notions about the way businesses are managed internally, the way networks of enterprises work together, and the way government sets the rules under which businesses and individuals make their choices.

One feature of the transformation seems particularly clear. Returning to an economy like that of the 1960s is not one of our practical choices.

Infertility: Medical and Social Choices

Americans spent an estimated $1 billion on medical care in 1987 to combat infertility (defined as a couple's inability to conceive after 12 months of intercourse without contraception). As many as half the infertile couples seeking treatment are ultimately unsuccessful, despite trying various avenues of treatment.



Among those seeking treatment, 85 to 90 percent are treated with conventional medical or surgical therapies, which are still the most successful and widely used approaches to overcoming infertility. This category includes ovulation induction, surgery, and artificial insemination. Two new, noncoital reproductive technologies—in vitro fertilization (IVF) and gamete intrafallopian transfer (GIFT)—offer hope to infertile couples who could not be successfully treated otherwise. These two techniques are being practiced with increasing frequency, but proficiency varies widely.

Infertility affects an estimated 2.4 million married couples (data from 1982). Although there has been no increase in either the number of infertile couples or the overall incidence of infertility in the population, the number of office visits to physicians for infertility services rose from about 600,000 in 1968 to about 1.6 million in 1984. Concomitant increases occurred in the memberships of the American Fertility Society and other professional organizations for physicians who treat infertile patients.

Preventing infertility is difficult. Nevertheless, an estimated 20 percent of infertility in the United States—that resulting from chlamydia, gonorrhea, or other sexually transmitted diseases—is preventable.

Surrogate motherhood is more a social solution to infertility than a medical technology. An estimated 100 surrogate mother arrangements may be concluded annually in the coming years. The legal status of these

arrangements is today unsettled, although legislation addressing some aspects of surrogacy has been passed in Louisiana, Arkansas, Nevada, and Kansas. State court decisions have consistently found surrogacy contracts to be unenforceable, even though they have split on whether the contracts are legal.

In addition to offering hope to some infertile couples, in vitro fertilization permits researchers to view for the first time human reproduction in progress. Understanding the interactions between egg and sperm has potentially broad application not only for conception, but for contraception as well. Researchers seeking Federal funding to work in this area, however, have faced the stifling effects of a de facto moratorium since 1980 on Federal funding of research involving human in vitro fertilization.

U.S. public policy related to infertility is difficult to establish because of a wide range of sometimes conflicting ethical views. Concerns focus on three principal ethical issues—the right to reproduce, the moral status of an embryo, and research with patients.

At least eight other nations (Australia, Canada, the Federal Republic of Germany, France, Israel, the Netherlands, Sweden, and the United Kingdom) have enacted legislation or issued major Government reports on assisted reproduction. In the United States, nine policy issues related to infertility confront Congress:

- collecting data on reproductive health;
- preventing infertility;
- information to inform and protect consumers;
- providing access to infertility services;
- reproductive health of veterans;
- transfer of human eggs, sperm, and embryos;
- recordkeeping;
- surrogate motherhood; and
- reproductive research.

Infertility's Emotional Toll

You find yourself experiencing feelings that you have never had before. Sometimes you are depressed when you never used to be, or you avoid situations that have anything to do with children. Your thoughts over the last 6 months include:

Why is this happening to me?

I must have done something wrong to deserve this.

I have to keep an important part of my life secret.

I have nobody I can talk to about this.

Sex on schedule takes all the joy out of making love.

Nobody understands how I feel, even my spouse.

I'm angry all the time.

I feel as if everything in my life is on hold.

I have a lot of trouble sleeping.

I'm always tired lately.

I've lost my self-confidence.

I feel like a failure in everything in my life.

I feel sad and alone.

I'm afraid my spouse will give up on me.

We don't have fun anymore.

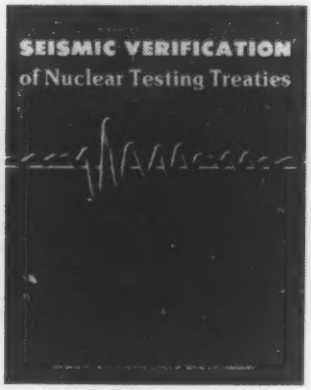
We don't fit in with our friends; they all seem to be into children.

My family can't support me like they used to, especially on special occasions when children are the center of attention.

If I could just stop trying so hard, maybe we could have a baby.

Seismic Verification of Nuclear Testing Treaties

Technologies that were originally developed to study earthquakes may now enable the United States to verify a treaty with the Soviet Union to further limit the testing of nuclear weapons.



Underground nuclear explosions release their energy in less than one-millionth of a second, vaporizing rock and creating vibrations that travel through the Earth as seismic waves. By recording and analyzing these waves, seismology plays a central role in verifying arms control agreements that limit the testing of nuclear weapons.

Present treaties limit the U.S. and U.S.S.R. to testing underground and at yields no greater than 150 kilotons (kt). (One kt is approximately the explosive power of 1,000 tons of TNT; the bomb dropped on Hiroshima was approximately 13 kt.) Although these treaties have had positive environmental and arms control impacts, they have not prevented the development of new bombs and warheads. Consequently, public interest in a complete test ban or a much lower threshold remains strong and each year a number of proposals are brought before Congress to further limit the testing of nuclear weapons.

Principal Findings

Monitoring—Seismic monitoring networks are now extremely sophisticated and have remarkable capabilities. A high quality network could detect and identify with confidence nuclear explosions well-below 1 kt, if no attempt were made to muffle the seismic signal or spoof the seismic network. However, a country attempting to test clandestinely would presumably use every means to reduce the size of the seismic signal created by the explosion and fool the monitoring network. For example, a potential evasion method

would be to muffle a small clandestine nuclear explosion by setting it off in a large underground cavity and attribute the muffled signals to a large chemical explosion that is simultaneously set off under the guise of legitimate industrial activity.

Seismic monitoring capability is limited by our ability to demonstrate that all credible evasion scenarios could be defeated. Monitoring small explosions is more difficult because there are more methods of evasion and more innocent signals (e.g., earthquakes and large quarry blasts) from which such a test would need to be distinguished. Countering evasion scenarios should be approached through a combination of seismic methods, treaty constraints, and other monitoring methods. Consequently, the capabilities of any given seismic monitoring network will depend on how the task is approached and what supplementary provisions are negotiated within the treaty.

Ultimately, there will always be a limit to the capability of any given monitoring network, and hence there will always be a threshold below which the uncertainty of any monitoring system will increase. Determining the level that cannot be adequately verified is a political judgment of the point at which the risks of a treaty outweigh its benefits.

How Low Can We Go?—Treaties with low-yield testing limits would require seismic stations throughout the Soviet Union, provisions (e.g., notification, onsite inspection) to handle large chemical explosions, and stringent testing restrictions to limit opportunities for evading the monitoring network. If such restrictions could be negotiated, most experts believe that a high-quality, well-run network of internal stations could confidently monitor a threshold of around 5 kt. Expert opinion about the lowest yields that could reliably be monitored ranges from 1 to 10 kt, depending on judgments about what technical provisions can be negotiated, how much the use of high frequencies will improve our capability, and what levels of confidence are necessary to ensure that the Soviet Union would not risk testing above the threshold. Lower thresholds or even a complete ban could still be considered verifiable if, taking both seismic and non-seismic methods into account, the significance of undetected violations (should they occur) would be outweighed by the benefits of such a treaty.

Soviet Compliance—Extensive statistical studies have examined the distribution of estimated yields of explosions at Soviet test sites. The results conclude that Soviet testing is consistent with compliance with the 150 kt limit of the Threshold Test Ban Treaty. The distribution of Soviet tests indicates that about 10 (out of over 200) Soviet explosions since the signing of the Threshold Test Ban Treaty in 1974 could have estimated yields with central values above the 150 kt threshold limit, depending on how the estimate is made. However, all of these estimates are within the 90 percent confidence level that one would expect if the actual yields were 150 kt or less.

Verificatior of the TTBT and the PNET—The 1974 Threshold Test Ban Treaty and the 1976 Peaceful Nuclear Explosions Treaty remain unratified in part because of concerns that the size of Soviet explosions

cannot be measured with adequate confidence. As a solution to the problem of uncertainty in yield estimation, the use of an on-site hydrodynamic method, called CORRTEX, has been proposed. The drawbacks compared to seismic methods are that CORRTEX requires pre-notification and full cooperation of the host country to the extent that foreign personnel and their equipment be allowed on the test site for each test. Furthermore, such hydrodynamic methods have limited application for monitoring a low-yield treaty and none for detecting clandestine testing. If the Soviet test site were seismically calibrated and advanced seismic methods were utilized, the uncertainty in seismic yield estimation could be reduced to a level comparable to CORRTEX and fufill the other functions as well. CORRTEX could be used to complement seismic methods by confirming the yields of the calibration shots.

The Quality of Medical Care: Information for Consumers

OTA examined whether valid information on the quality of medical care could be developed and made available to the public to guide their choices of physicians and hospitals. Recent changes in how physicians and hospitals are paid have raised concerns that providers facing restricted budgets and low payment rates might skimp on services to the detriment of patients' health and that third-party payers will seek low-cost providers without sufficient attention to the quality of care. Advocates of better quality-of-care information expect that individuals and organizations would use improved consumer information to select hospitals and physicians, thereby exerting leverage on these providers to improve their performance.

After examining various ways to measure the quality of care, this OTA report concluded that several of the possible indicators can provide useful information to guide individuals and organizations in selecting physicians and hospitals. Although none of the possible measures can conclusively evaluate quality across the full range of medical care, several could be used to flag areas for further exploration. In evaluating a specific physician or hospital, OTA advises consumers to combine information from more than one indicator and to draw information from more than one year.

Of the indicators examined, formal disciplinary actions by State medical boards provide the most valid information about poor-quality physicians. In addition, the results of hospital accreditation, physicians' practicing in the area of their training, and patients' ratings of the interpersonal aspects of their care have good validity.

OTA places high priority on improving information on indicators that are already being disseminated and used, namely hospital mortality rates, adverse events, sanctions of the Department of Health and Human Services

(HHS) based on recommendations by peer review organizations (PROs), and physician specialization. OTA also gives higher priority to efforts to identify and to improve the quality of physicians and hospitals whose performance falls below acceptable levels than to efforts to distinguish among good-quality providers.

In the course of evaluating the indicators, OTA identified several deficiencies in the field of quality assessment. Current techniques do not adequately adjust for patient and environmental factors than may influence patients' health and satisfaction independently of the quality of care. There is also a dearth of necessary data and a lack of uniform methods to code, collect, and report data. Further, although some information, most notably hospital mortality rates, is becoming available to the public, other relevant quality information, such as the results of hospital accreditation, is regularly compiled but not publicly available. Finally, how individuals and organizations use quality-of-care information and how information can most effectively be communicated remain largely unexplored. OTA developed policy options that Congress could adopt to improve quality assessment techniques, to ensure the quality of assessments, to improve the availability of required data, and to make quality-of-care information more available to the public.

SDI: Technology, Survivability, and Software

The ultimate goal of the Strategic Defense Initiative (SDI) is to create defenses effective enough to "eliminate the military threat" of nuclear ballistic missiles and perhaps lead to an arms control agreement with the Soviets to eliminate the missiles themselves.

In mid-1987, the SDI Organization (SDIO) proposed taking the first steps toward developing and deploying a "phase one" ballistic missile defense (BMD) system in the mid-1990s.

Elements of a Phase One Strategic Defense System

- High-altitude satellites intended to detect and track ballistic missiles as they rise from their launchers
- A few thousand space-based interceptors (SBI) located on a few hundred satellite "garages" or "carrier vehicles" in low-earth orbit, intended to collide with missile boosters and warhead-carrying stages (called "post-boost vehicles")
- An infrared sensor system, either based on satellites or launched from the ground to high altitides during an attack, intended to detect and track missile warheads and decoys
- Several hundred ground-based interceptors intended to collide with missile warheads before they reentered the atmosphere

If phase one worked as planned, it might protect a substantial fraction of certain kinds of targets, such as ICBM silos. SDIO officials say that by reducing Soviet attack capabilities, this system would significantly enhance nuclear deterrence. Such a system might also offer general protection against small or accidental ballistic missile attacks.

The second and third phases of BMD development and deployment are less well defined. These additional phases, however, would be essential to retain the capabilities of phase one in the face of future Soviet countermeasures and to extend BMD protection to urban and industrial targets.

Possible Elements of Phases Two and Three

- Additional and improved space-based interceptors
- Ground-based interceptors designed to attack reentry vehicles inside the atmosphere
- "Interactive Discrimination" devices, perhaps neutral particle beam accelerators, to help distinguish between decoys and reentry vehicles disguised as decoys
- Directed-energy weapons, such as lasers to attack future missile boosters too fast to be reached by space-based interceptors

Principal OTA Findings

1. Many years of BMD research have led to impressive technical achievements, but important technical issues remain to be resolved before the feasibility of reaching SDI goals can be determined. The SDIO has initiated programs to address most, if not all, of these issues.

2. The effectiveness of a first-phase BMD system in the mid-to-late 1990s would depend on several uncertain factors, including:

- affordably producing the system proposed;
- deploying the system on the schedule proposed;
- the effectiveness of likely countermeasures by the Soviets; and
- the numbers of Soviet weapons that exist by then and the Soviet attack strategy.

3. The feasibility of modifying and adding to the phase one system to meet a changing Soviet threat in the year 2000 and beyond will remain uncertain for some time. Commitment in the early 1990s to full-scale development and deployment of a phase one system would occur before most of the experimental evidence on succeeding phases is complete. Thus, a major issue will be whether Congress has enough confidence in the second and third phases of the system to commit to development and deployment of the first phase.

4. The survivability of a space-based BMD system is hard to estimate, because it would depend on the specific weapons attacking it, the countermeasures against those weapons, the tactics used by each side, and the inevitable uncertainties of battle. For example, nuclear-armed anti-satellite weapons launched from the ground could seriously threaten a first-phase or second-phase BMD system.

5. OTA found little analysis of space-based threats to BMD system survivability. SDIO analyses have generally assumed that U.S. BMD technologies would remain superior to Soviet technologies. The SDIO and its contractors appear not to have studied seriously the possibility that the United States and the Soviet Union would both field comparable BMD systems. Moreover, the Soviets would not need to achieve BMD capabilities to begin to challenge U.S. control of, or even access to, space, since most BMD weapon technologies would have anti-satellite applications before they reached the levels of power and precision needed for BMD.

6. Because of the nature of software and past experience with large, complex software systems, there may always be irresolvable questions about how dependable BMD system software would be. Moreover, no adequate models exist for the development, production, testing, and maintenance of full-scale BMD software systems. The relatively slow rate of improvement in software engineering technology makes it appear to OTA unlikely that questions about BMD system software dependability would be resolved in the foreseeable future. SDIO officials, however, argue that software programs will be manageable and that simulation testing to permit sufficient confidence in the system will be possible.

7. There is broad agreement in the technical community that significant parts of the research being carried out under the aegis of SDI are in the national interest. Disagreement, however, centers on whether this research is best carried out within a program that is strongly oriented toward supporting an early 1990s BMD deployment decision that includes system development as well as research elements.

OTA prepared this report in response to a provision in the fiscal 1986 defense appropriations bill (Public Law 99-190).

Grassroots Development: The African Development Foundation

The African Development Foundation (ADF) is a small U.S. development assistance agency faced with a big task: supporting grassroots development in Africa. Congress created ADF in 1980 to "enable the poor to participate in the process of development." Congress hoped that this approach would be more successful than other U.S.-funded development assistance programs because the lack of people's participation was often cited as a critical reason for program failure. ADF's purposes are to support local self-help activities for community development, to stimulate expanding participation of Africans in their development, and to encourage the growth of African development institutions. The Foundation opened its doors in 1984 and its appropriations grew to $7.0 million by 1988.

OTA's assessment confirmed the validity of the assumptions on which

ADF was created and found that most ADF-funded projects were doing reasonably well. While identifying a number of areas for improvement, OTA concluded the Foundation's reauthorization is justified. ADF would need additional funding, however, if it is to implement the recommended improvements without reducing the funds available for new grants.

ADF's Funding Program

Between 1984 and 1987, ADF awarded grants to 114 projects in 19 countries, distributing a total of $10.3 million. Individual grants ranged from $700 to $250,000, and most commitments are for 2 to 3 years. Projects average approximately $90,000. Two-thirds of the projects have agricultural activities as a major component; some support other rural activities, such as potable water supply; and one-fifth provide aid to urban organizations. Funded groups use ADF money to repair wells, build small-scale irrigation systems, plant vegetable gardens and orchards, improve animal health, rent tractors, raise chickens, form cooperatives, and conduct many other activities. In addition to funding grassroots groups, ADF funds support organizations, enabling them to provide services such as training, credit, and technical assistance to grassroots groups. In 1987, ADF evaluated 10 of its projects. The first grants for research were awarded to Africans in 1986.

Findings About ADF-Funded Projects

Promoting participation is an explicit part of ADF's mandate. ADF also strives to achieve results that are sustainable and replicable because of ADF's obligation to foster social and economic development. Selection of technologies affects project performance in each of these areas. OTA teams visited a total of 12 ADF-funded projects in 6 countries in western, eastern, and southern Africa. OTA's major findings about project performance related to these four critical issues—participation, results, sustainability, and replicability—are:

- OTA judged that one-half of the 12 African groups visited by OTA teams have a high degree of overall participation in the ADF-funded activity; one-third, however, rated low on participation. Generally, participants were representative of the community, agreed that the project addressed a need, and shared equitably in costs and benefits. On the other hand, participants usually did not take part in evaluation and financial decisionmaking and women rarely participated in project management. A third of the projects rated low on participants' acceptance of the proposed technologies, their share in project management, women's access to the project, and participatory provision of technical assistance.
- Since most projects were in an early stage of development, future results had to be estimated. Ten projects were judged likely to have a positive impact on the social and economic development of the poor in the locale, but the level of impact ranged from significant to negligible.

- OTA teams estimated that almost all ADF-funded activities have a high or moderate potential to be sustained over the next 3 to 5 years, although not necessarily in the same form as proposed. Community support was the strongest reason for sustainability. However, lack of careful economic and environmental planning threatened longer-term sustainability.
- The activity or some management aspect of most projects was rated to have a moderate or high degree of replicability in the region or country. Self-help processes were found more replicable than many of the technologies used. The relatively high cost of these technologies was a major constraint to replicability of project activities.

Improving ADF's Funding Program

Some of ADF's difficult choices in translating its mandate into action have had positive effects. ADF has a committed staff with considerable African experience and has hired qualified Africans, as staff and contractors, to carry out its program. ADF's grant-making processes are generally flexible and responsive, and ADF grants have supported the growth of grassroots leadership and organizational capacity.

In other areas, however, ADF could do better. Some projects have deficiencies regarding participation, sustainability, and replicability. While the projects visited were judged likely to attain short-term objectives and benefit some people, the performance of a number of them raised questions about overall impact and longer-term sustainability. In addition, the underuse of ADF's African field staff is inconsistent with ADF's mandate to promote the participation of Africans in the development process.

A number of high priority changes, consistent with its aim to support self-help efforts, would improve ADF's ability to meet its full mandate:

- Revise and clarify the roles of staff in their working relationships with applicants and grantees.
- Increase and improve ADF's analysis during the project approval process and facilitate better planning by applicants.
- Improve communication with managers of funded projects and more actively help them identify problems and resources during project implementation.
- Enhance the responsibilities of African staff in project identification, approval, and monitoring.
- Increase communication with other development organizations, especially those that assist similar recipient groups. Begin to develop country strategies to guide its work and identify ADF's role in each country.

Several lower priority but important changes also would contribute to ADF's effectiveness:

- Streamline the approval and start-up processes (which averaged 12.5 months for the 12 projects) and reduce unnecessary delays.

- Conclude agreements with African governments where appropriate. (Currently, ADF does not have agreements in 11 of 19 countries where it funds projects.)
- Address issues regarding the limited scope of ADF's current portfolio of funded projects, e.g., consider funding a more balanced mix of social and economic development activities.

Every suggestion carries a price tag. ADF should emphasize simple, inexpensive, and rapid methods to carry out these suggestions. But OTA estimates ADF will also need $500,000 to $700,000 per year in additional resources to implement the changes. It would be most effective to increase ADF's appropriations, without earmarking, even though this will increase ADF's percent of non-grant, operational costs (to nearly 50 percent from 43 percent in fiscal year 1987). This high portion of non-grant costs would be temporary, until appropriations for grants are increased, and can be regarded as a short-term investment in ADF's long-term effectiveness.

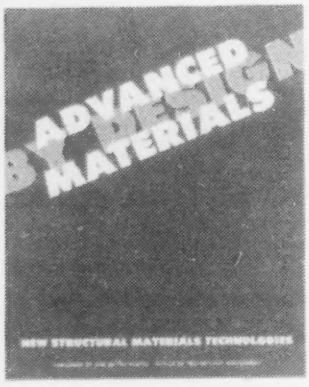
Lessons for Other Donors

Congress intended ADF to share what it learns from its successes and disappointments. The findings and methods of this assessment are relevant to the work of other development assistance agencies.

ADF can serve as a positive model in some aspects of managing funding programs, for example, maximizing local control by grant recipients, using Africans to provide technical assistance and conduct evaluations, and funding planning grants. Its generally effective congressional relations also could be instructive for other government-funded agencies.

Advanced Materials by Design: New Structural Materials Technologies

Materials account for as much as 30 to 50 percent of the costs of a wide range of manufactured products. New "advanced" structural materials that can reduce production costs and improve performance can give the United States a competitive edge in many products, including aircraft, automobiles, industrial machinery, and sporting goods.



The value of components produced in the United States from these advanced materials has been projected to grow from about $2 billion in 1988 to nearly $20 billion by the year 2000. However, despite its strong position in advanced materials technologies (developed largely as a result of military programs), whether the United States will lead the world in commercializing these materials is uncertain. The technologies are still in their infancy, and cost-effective use of advanced materials and fabrication processes has not been demonstrated in large-scale commercial applications. Potential U.S. commercial end users believe that major use of these materials will not be

profitable for about 10 to 15 years and have adopted a "wait and see" attitude.

In contrast, end user companies in several countries, notably in Japan, have initiated more aggressive programs to commercialize their evolving materials technologies and have succeeded in bringing some advanced material products to the market years in advance of comparable U.S. products. The manufacturing experience gained by this aggressive approach is likely to give these companies a significant competitive advantage in the growing world markets for advanced materials.

Advanced materials can be classified as metals, ceramics, polymers, or hybrids (composites) derived from these. They offer superior properties such as strength at high temperatures, high stiffness, and light weight compared to traditional metals such as steel and aluminum. In some cases, they make possible entirely new products and design approaches that would not be feasible with existing materials. OTA focuses on three promising categories of structural materials: ceramics (including ceramic matrix composites), polymer matrix composites, and metal matrix composites.

The Federal Government directly affects the development of advanced materials through funding of basic research, technology demonstration programs, and military and aerospace procurement of these materials and structures. The U.S. Government currently spends about $170 million per year for R&D on structural ceramics and composites, more than any other nation. The Department of Defense sponsors about 60 percent of this total.

Congress and the Reagan Administration have disagreed on the appropriate Federal role in establishing goals for advanced materials R&D. The congressional view expressed in the National Materials Act of 1984 is that advanced materials policies can be viewed as a group having generic importance to many Federal agency missions and commercial uses, but separable from them. Hence, in that congressional view, materials R&D priorities are appropriately designed at the national level. The Administration view has been that R&D priorities for advanced materials cannot be separated from applications and, hence, are best addressed by establishing priorities at the individual Federal agency level.

While a national policy approach to advanced materials R&D could provide a focus for individual agencies and for collaborative government and industry projects, it is difficult to address specific cost and performance requirements in commercial markets with such an approach. In particular, it may fail to produce materials or processes that are economically attractive to U.S. industry. So far, the policy debate has suffered from a poor definition of its objectives.

In many respects, the competetive challenges facing U.S. advanced materials industries are a microcosm of the challenges facing the U.S. manufacturing sector as a whole. Therefore, advanced materials policies cannot be viewed as a totally separate issue. The most effective way to address these policies is as one facet of a high-level, high-priority policy of strengthening the Nation's entire industrial base, including defense technology.

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Defining national policy goals for advanced materials is more difficult than for more traditional critical materials (mostly minerals), which generally revolve around conservation or stockpiling of scarce elements. This difficulty is due in part to the great diversity of advanced materials and their uses, and in part to the fact that the technologies tend to be driven by the specific performance requirements determined by specific uses.

OTA identifies four key Federal policy objectives that could accelerate the commercialization of advanced materials technologies in the United States:

1. encourage potential end users to make long-term capital investments in advanced materials;
2. facilitate government/university/industry collaboration in R&D for low-cost materials fabrication;
3. facilitate more effective commercial exploitation of military R&D investments where possible; and
4. build a strong advanced materials technology infrastructure to permit rapid exploitation of research results.

Educating Scientists and Engineers: Grade School to Grad School

The national goal of maintaining and invigorating a productive science and engineering work force demands efforts on three fronts. First, capable young people must be sought out and welcomed throughout the school years. Second, their individual talents must be nurtured by elementary and secondary schools and institutions of higher education. Third, they must perceive that there will be good, fulfilling jobs available when they graduate.

OTA finds that college students majoring in science and engineering are not only those who display early interest, high achievement, and drive; data indicate that one-quarter of them come from outside the academic (college-preparatory) curriculum track. Encouragement, preparation, and career opportunities can attract students into science and engineering even after they enter college.

The job market is too unpredictable to target specific personnel needs, so the goal of higher education, including that for science and engineering, should be to prepare students for an uncertain future by imparting a range of skills. The education of scientists and engineers must be both specialized enough to satisfy the ongoing demand for faculty and industry researchers, and general enough to allow students and recent graduates to respond to changing or unexpected national research priorities.

Supply Trends

America is unusual in that a majority of high school graduates attend college. In large part this is made possible by government and private financial aid that is awarded without regard to field of study. College students shift majors partly in response to perceived changes in the job market. Most shifts of science and engineering majors, however, are within these fields, rather than into or out of science and engineering altogether. Science and engineering baccalaureates have maintained a remarkably constant share (30 percent) of total baccalaureates (20 percent if only natural science and engineering baccalaureates are considered) for the past 30 years. While many of these graduates take science and engineering jobs, few attend graduate school.

The proportion of baccalaureates in science and engineering who go on to earn Ph.D.s, however, has never been constant. Graduate enrollments reflect the availability of fellowship and assistantship funding, and at the doctoral level, the outlook for research and development funding and employment.

Elementary and Secondary Education

Science and mathematics education are embedded in the American system. Good teachers are critical. They are only as strong, however, as their preservice and inservice training, support, and working conditions. Curricula, textbooks, testing, and tracking are all part of our mass education system; that system resists change and serves the aspirations of some students better than others.

Over the past 20 years, special programs have been used to encourage children's interest and proficiency in academics, especially in mathematics and science. These programs spark interest in ways that most classrooms do not. Based in the community or in the schools, with strong role models and individualized programs, they support students who often do not succeed in the regular classroom. Intervention programs such as these enrich the experiences and attitudes of minorities and females toward science and mathematics. Some programs draw on university experts and the latest in testing and computer technologies; many more work on shoestring budgets with egg cartons and volunteers. While there is no single model of success, intervention techniques have been shown to be effective. If these techniques could be more widely applied in schools, a larger and more diverse population of students might pursue science and engineering as careers.

Informal education in 150 science centers nationwide, as well as summer science camps and educational television, also helps remove barriers to learning imposed by tracking, testing, and teacher expectations in schools. Intervention programs and informal education cannot replace schools, textbooks, and teachers; however, they can be a source of innovation and improvement for elementary and secondary schools.

College Admissions Tests

Standardized tests are used extensively in college admissions—particularly the Scholastic Aptitude Test (SAT) and American College Testing (ACT) Program. For white males, standardized test scores have been valid predictors of academic performance in the freshman year. There is controversy surrounding the disparity between girls' high performance in mathematics classes but lower scores on standardized mathematics tests. How college admissions officers weigh (or do not use at all) these scores relative to other factors, especially in the case of female and minority applicants, is the overriding issue in this controversy.

Higher Education Environments

Undergraduate participation in research, quality teaching, and supportive, individual attention to student development are the hallmarks of a productive undergraduate education—one that encourages students to continue in science or engineering. This nurturing, research-oriented environment is found in various undergraduate institutions—private liberal arts colleges (especially 100 or so "research colleges"), women's colleges, historically Black colleges and universities, and some technical colleges and universities. These institutions make special contributions to science and engineering. Many characteristics of these environments could be replicated at other institutions.

At the graduate level, Ph.D. production is concentrated in about 100 of the 330 universities that award science and engineering Ph.D.s. These institutions have the faculty, facilities, equipment, and other resources to increase the production of quality Ph.D.s if necessary. Direct support of graduate students through fellowships and traineeships, as well as Federal programs that improve the research climate on campus—infrastructure, new centers, research funding—foster Ph.D. production.

Strategies

There are two broad strategies for Federal action to replenish and enhance the supply of scientists and engineers. They complement each other and would operate best in tandem. The first is a retention strategy. Its primary goal is to retain undergraduate and graduate students well along in the educational process by reducing attrition, and especially in the case of undergraduates, to encourage them to go on for Ph.D.s. Such short-term, proven retention efforts could modestly increase the supply of scientists and engineers within a few years. The second strategy is an attempt to enlarge the base of potential scientists and engineers over the long term by recruiting more and different students into science and engineering study. Such a recruitment strategy entails working with schools and colleges, and with children, teachers, and staff, to improve elementary and secondary mathematics and science education. Together these two strategies can raise the quality, broaden the demographic composition, and (if necessary) increase the number of young scientists and engineers to meet near-term research and development needs and prepare for longer-term, uncertain needs.

Key Findings

Elementary and Secondary

- Interest in majoring in science or engineering in college is correlated with mathematics preparation, hands-on laboratory and field experience, research participation, high expectations, high-quality teaching, and placement in the academic curriculum track or in a science-intensive school.
- Elementary and secondary education as a whole needs renovation; mathematics and science are but one part of the system.
- Federal programs, in particular National Science Foundation (NSF) teacher training and curriculum development, and high school research participation sponsored by NSF and the mission agencies, have had some success with the children and teachers that they reach.

Undergraduate

- Interest by freshmen in science and engineering is declining slightly, while majors such as business are increasingly popular. Science and engineering students continue to have higher grade point averages and SAT scores than those entering other majors.
- Major research universities, in absolute terms, produce the largest number of students who go on to Ph.D.s in science and engineering. But technical institutions and private liberal arts colleges with some active research produce, in relation to their size, a remarkable number of students who eventually earn Ph.D.s in these fields.
- Science and engineering majors are similar to other students in their sources and extent of financial aid. Undergraduate loan burdens do not seem to affect decisions by the majority of students to pursue graduate degrees.

Engineering

- Engineering education needs to balance the curricular tug-of-war between the practice-oriented pull of industry and the research, analysis-oriented push of universities.
- The complexity and cost of equipment for teaching engineering is high and rising dramatically, and many engineering schools are unable to keep up.
- Foreign graduate students have been attracted by the quality of American engineering education and have compensated for the dearth of U.S. citizens who are entering graduate school.

Graduate

- Graduate education in the sciences is a long (an average of 7 to 8 years post-baccalaureate) and expensive process; a diversity of support mechanisms (teaching assistantships, research assistantships, and fellowships) sustain students en route to receipt of the Ph.D.

- Increased Federal funding has a direct positive effect on Ph.D. production. Fellowships and traineeships in particular have been straightforward ways to increase Ph.D. production in science and engineering.

Policy Options to Improve Science and Engineering Education

Recruitment—Enlarge the Pool

- Elementary and secondary teaching: encourage and reward teachers; expand support for preservice and inservice training.
- School opportunities: reproduce science-intensive schools, adjust course-taking and curricula, review tracking, and revise testing.
- Intervention programs: increase interest in and readiness for science and engineering majors; transfer the lessons from successful programs; encourage sponsorship from all sources.
- Informal education: increase support of science centers, TV, fairs, and camps.
- Opportunities for women: enforce Title IX of the Education Amendments of 1972 and provide special support and intervention.
- Opportunities for minorities: enforce civil rights legislation and provide special support and intervention.

Retention—Keep Students in the Pool

- Graduate training support: "buy" Ph.D.s with fellowships and traineeships; these people are most likely to join the research work force.
- Academic R&D spending: bolster demand and support research assistants, especially through the mission agencies.
- Foreign students: adjust immigration policy to ease entry and retention.
- Undergraduate environments: support institutions that reward teaching and provide role models, such as research colleges and universities, and historically Black institutions.
- Hands-on experience: encourage undergraduate research apprenticeships and cooperative education that impart career skills.
- Targeted support for undergraduates: link need- or merit-based aid to college major.

Strengthen Federal Science and Engineering Education Efforts

- National Science Foundation as lead science education agency: underscore responsibility through the Science and Engineering Education Directorate for elementary through undergraduate science programs.
- Federal interagency coordination and data collection: raise the visibility of science education and the transfer of information between agencies and to educational communities.

Commercializing High-Temperature Superconductivity

The race to commercialize high-temperature superconductivity (HTS) is on. Recent discoveries of superconductivity (total loss of resistance to electricity) at record high temperatures open up the possibility of dramatic new applications ranging from ultrafast computers to magnetically levitated trains. Although the United States is strong in the science of HTS, Japanese firms are pursuing commercial applications more aggressively. The U.S. Government, for its part, is promoting HTS in its traditional way: support for science, coupled with R&D funded by the Defense Department and other mission agencies. OTA's analysis indicates that this approach will likely be insufficient to meet foreign competition.

Industry Strategy: By and large, Japanese companies have been more active in pursuing the commercial potential of HTS. They have more people at work, many of them applications-oriented engineers and business planners charged with thinking about ways to get HTS into the marketplace. Japanese managers are confident that investments now will pay off—some time and some way.

With several notable exceptions, U.S. firms have been reluctant to commit people and dollars to HTS at comparable levels, given its uncertain prospects. American managers—under pressure to show short-run profits—have been inclined to wait and see what the laboratory yields. As the scientific race becomes a commercial race, Japanese firms could quickly take the lead. Indeed they may already be doing so.

Government Response: Firms in both countries look to government R&D for a technology base that can help support commercialization. The U.S. Government will put about $95 million into HTS R&D during fiscal 1988, substantially more than the Japanese Government. The Departments of Defense (DoD) and Energy (DOE) will spend about three-quarters of that, the National Science Foundation about 15 percent.

This approach, typical of postwar Federal technology policy, has put the United States in a strong position in the science of HTS. But it may well leave this country behind Japan in commercialization. Neither DoD nor DOE can be expected to provide broad support for industrial R&D—that's not their job. And little R&D support is going to industry, still less to firms that expect to compete in the civilian marketplace. HTS technologies stemming from DoD R&D may eventually find their way into the commercial market, but spinoffs are less likely today than in earlier years.

The Broader Problem: The pattern already evident in HTS resembles that in other troubled American industries. The United States dominates in science, and American companies often make the major technological breakthroughs. But as industry moves along the learning curve, the

competition quickly comes down to engineering and manufacturing, where Japanese firms excel and U.S. firms continue to lag.

The Federal Government's traditional, mission-based approach to supporting technology development worked well for several decades. But the world has changed. Military technologies have grown steadily more specialized, the defense sector more isolated from the rest of the economy. If DoD R&D funding was ever a cornucopia for U.S. industry, it is no longer.

Measures designed to stimulate commercial innovation indirectly—through tax policy, or relaxed antitrust enforcement—have not proved to be an adequate response to new international competition. Although such policies have been in place since the early 1980s, U.S. industry invests proportionately less in R&D than West German and Japanese firms. Indeed, the gap has widened.

Strategies for Commercializing HTS

OTA's report also analyzes three strategies through which the Federal Government might foster commercialization of HTS:

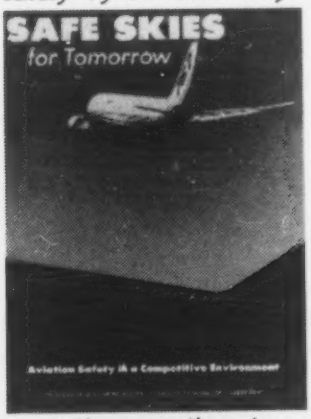
- **Flexible Response:** This is the de facto U.S. strategy toward HTS, characterized by support for science and defense technology development. It builds on the notable strengths of the U.S. system, including high-quality university research and unmatched resources for promoting advanced technologies of military importance. Its major weakness is the dearth of funds going to firms that expect to compete in the civilian market for HTS.

- **Aggressive Response:** This strategy would differ in three major ways from current policies: 1) NSF would have more money for HTS—in essence, an insurance policy against missed opportunities in basic science; 2) the Federal Government would share in the costs of industrial R&D consortia, so as to promote long-term, high-risk ventures; and 3) a working group of experts from industry, universities, and government would help shape industry consensus on the R&D agenda and allocate funds to those proposed consortia willing to make the longest time commitments and self-finance the highest fraction of R&D costs.

- **A Federal Technology Agency:** The report analyzes three variants: 1) a cabinet-level science and technology agency; 2) institutional changes that would substantially raise priorities for engineering research; and 3) direct support for civilian and commercial technologies. Although none of the alternatives under this strategy offer near-term support for HTS, the second two could hold promise for future technologies.

Safe Skies for Tomorrow: Aviation Safety in a Competitive Environment

Lured by lower fares since deregulation, thousands of Americans travel safely by air each day. Although no story about air safety seems too unimportant for media attention, the United States has a commercial aviation safety record that has continued to improve over time and ranks among the best in the world.



Passenger ranks have grown by 10 percent annually over the past 3 years, totaling 480 million in 1987. Increases in commercial air traffic have strained industry and government equipment and personnel, as well as airports and air traffic control (ATC), requiring the entire system to perform consistently at peak ability—a requirement not easily met. Over the past decade each airline has made major changes in operating practices to control costs, and the effects of these changes on safety are still being evaluated. The Federal Aviation Administration (FAA) has been scrambling to catch up, as it has been hard hit by budget cuts and by personnel and organizational problems and has fallen behind in both numbers of staff and technical expertise.

Plans to build more runways and modernize airports have been stymied by interjurisdictional disputes over noise and land use that are unlikely to be resolved in the near term. ATC system renewal moves at glacial speed—slowed by Federal procurement delays and personnel shortages, inadequate system planning, development difficulties, and tight budgets

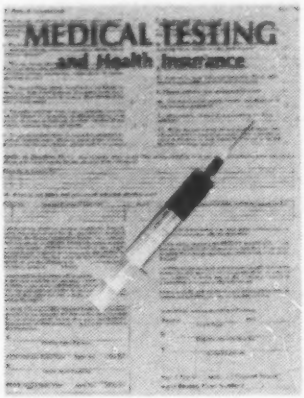
Human performance, weather, aircraft component failure, and the air traffic environment are the major causal factors in commercial aviation accidents. Major improvements to air safety can come through solutions to problems of human performance; and this would require consistent support for R&D, analysis, and implementation of results. However, FAA programs to understand human error and to enhance performance of controllers, mechanics, and cockpit crews are inadequate. In addition, substantial contributions to greater safety could be made by technologies to improve prediction, detection, and interpretation of severe local weather conditions and to communicate and coordinate this information between ATC and the cockpit. Finally, warning signs point to a potential for deterioration of safety in ATC itself. Continued vigorous traffic growth and increased traffic densities for longer periods of time at more airports could outstrip the capabilities of today's air traffic system. Interim steps to manage demand and to modernize the ATC system until the major improvements of the National Airspace Plan are available in the 1990s are necessary to ensure the present level of safety. However, decisions about managing demand and allocating air traffic system resources have major economic consequences for airlines—spelling success or failure for some in precarious financial

condition. Such decisions thus pose serious equity issues and require careful scrutiny, public debate, and deliberate decisionmaking.

OTA identified ways to improve FAA safety management and air system operations and approximate costs for doing so. Improvements in safety management include streamlining FAA's internal organization; increasing numbers of inspectors, controllers, and technicians; raising levels of technical expertise; and making safety FAA's primary responsibility so as to ensure a system-wide safety program. Operating improvements include expanding ATC capacity and capability, enhancing human performance, and upgrading weather programs and air/ground communications.

Medical Testing and Health Insurance

Advances in medical testing are making practical the capability to identify individuals who are more likely than others to develop serious diseases. The use of such tests by private insurers may make health insurance unavailable or too costly to a number of presently insurable persons and their dependents, placing increasing demands on public sector spending for health care. The rapid growth of self-insurance among large employers raises similar issues related to medical testing in the workplace.



The medical tests most commonly used by insurers are routine blood biochemical profiles and urinalyses. These blood and urine tests are usually reserved for selected high-risk applicants and are directed at uncovering evidence of diabetes and underlying kidney, liver, and cardiovascular diseases. Insurers may also screen for specific prescription drugs (for evidence of compliance with medically prescribed treatment or of a medical condition that the applicant has not divulged); for drugs of abuse (e.g., cocaine); and more recently, for evidence of infection with HIV (human immunodeficiency virus—the AIDS virus).

New methods for detecting incipient or latent disease and even for predicting disease in healthy persons are being developed, particularly through recombinant DNA technology. While insurers may not find it cost-effective to use these tests in screening applicants, they may become aware of the results of such testing by the applicant's physician. Thus, the future impact of medical testing on an applicant's insurability will depend initially on the infusion of these future tests into medical practice rather than on the direct use of these tests by insurers in the underwriting process. If widely used by the medical community, insurers then may have to adopt such testing to avoid the problem of adverse selection; i.e., applicants who are motivated to purchase insurance because they are aware of a medical problem that is not yet evident to the insurance underwriter.

There are inherent limitations on the accuracy and reliability of all clinical laboratory tests. However, in addition to actions generally designed to

improve test accuracy and reliability, some States have addressed the question of when it is appropriate to use particular tests. The use of a particular test could be prohibited or limited to specifically defined circumstances—such as some States have done in prohibiting HIV-antibody testing for insurance or employment purposes and in limiting the circumstances in which employers can require their employees to submit to urine drug testing. Or there might be a requirement that a test be sufficiently accurate in the specific circumstances in which it is to be used, such as one State has done in HIV-antibody testing in insurance underwriting.

Is the controversy over health care coverage for HIV-infected persons a unique situation or a paradigm for future actions? A fundamental issue is whether persons with HIV-related diseases have a special claim on health care resources over persons afflicted with other catastrophic illnesses. Since the extension of Medicare coverage in 1972 to include end-stage renal disease (ESRD) and the attendant high costs of the ESRD program, concerns over costs have been an effective barrier against a disease-by-disease approach to health care coverage for catastrophic illnesses. Thus, while coverage for HIV-related diseases could be provided through the same methods as for catastrophic illnesses in general, the overriding issue is whether catastrophic illnesses are addressed generically or on a disease-specific basis.

Power On! New Tools for Teaching and Learning

American public schools have acquired close to 2 million computers in this decade, along with a wide range of educational software. In 1981, fewer than one school in five had a computer. Today, almost all do, and over 90 percent have VCRs as well. In addition, distance learning projects are proliferating: 35 States have projects or plans to deliver instruction via satellite or other electronic communications systems. This dramatic growth reflects the desire of school districts, administrators, teachers, and parents to use new learning technologies.

Computers are widely distributed, and student access has improved. But most schools do not have enough computers to make them a central tool of instruction. U.S. public schools average 1 computer for every 30 students, but there are wide variations in availability of computers across districts and States, and between students in relatively poor schools and those in more affluent schools. School size is a major determinant—larger schools have proportionately fewer computers. Reflecting this, black students, who tend to be in larger schools, typically have less access to computers than do white students, especially at the elementary school level. Students with limited English proficiency have the lowest access of all. Overall, those students who use computers do so an average of little more than 1 hour per week.

There is no one "best use" of technology, but there are many promising applications. The varied capabilities of the technologies are key to their power. New interactive technologies are now contributing to improvements in learning. They can play an even greater role by helping children acquire basic skills as well as more sophisticated learning strategies, so that they can continue to acquire and apply knowledge over their lifetimes.

Educational technologies are not self-implementing. They do not replace the teacher. Investments in the technology will only be effective if teachers receive training and support. But only one-third of the Nation's teachers have had even 10 hours of computer training, and most of it has been devoted to learning about computers, not how to teach with computers. Less than one-third of all recent education school graduates consider themselves prepared to teach with computers.

For most teachers, using computers makes their job more difficult at first, but few would choose to return to teaching without computers. If teachers are to use technology tools effectively, they must be provided training in the skills needed to work with technology, education that provides vision and understanding of state-of-the-art developments and applications, support for experimentation and innovation, and—perhaps most valuable of all —time for learning and practice. These elements should be a part of teacher preparation and inservice teacher training. As technology changes and research provides better understanding of how children learn, teachers will require continuing support.

There are over 10,000 software products on the market today intended for educational use in school or at home. Many are for drill and practice, although advances in technology have allowed development of more complex software applications. Distribution of software titles across subjects is uneven, but generic programs for word processing, data management, and desktop publishing offer teachers flexibility for a range of classroom uses.

Despite steady improvement, the quality of educational software could be much better. Increased capacity of hardware and advances in programming have removed many technological barriers, but economic risks in the market lead software publishers to play it safe and offer products that are familiar to most teachers. The result is a relatively homogeneous supply of software products that fall short of the technology's potential. Reliance on the private sector alone will probably not yield an adequately diverse, innovative, and responsive set of educational software products. Because affordable and effective educational software is critical to the success of interactive technology in schools, Federal, State, and local governments will need to play larger roles in support of software development.

Technology is changing rapidly, but educational technology R&D is not keeping up. The absence of a coordinated Federal policy, limited and short-term funding, erratic political support, and disorganized R&D efforts across agencies have resulted in delayed or lost opportunities. A substantial investment in R&D is needed now to exploit more fully the power and

potential of technology for education. Among the most promising research directions are:

- intelligent tutoring systems that are responsive to the individual learner;
- applications that exploit the computer's ability to be a multimedia controller, enriching curriculum with video, graphic, and audio components;
- simulations, microworlds, and laboratories that extend understanding through exploration, manipulation, and guided discovery;
- integrated tools and "intelligence extenders" that help students move beyond low-level tasks and concentrate on more demanding problem solving skills;
- new assessment measures that track learning, diagnose students' conceptual understandings, and evaluate the attainment of complex skills;
- design tools, "authoring systems," and "knowledge kits" that enable teachers to create and customize their own teaching materials; and
- new curricula, based on the skills students need in the information age.

Research in cognitive science, developments in information technology, and schools and teachers willing to experiment, all create today's "window of opportunity" for improving education. At the current rate of investment, the Nation can expect continuing experimentation in some schools, steady but slow improvement in software, and spotty access to the technology by students. If the Nation wishes to accelerate realization of the educational potential of the technology, a greater investment will be necessary. Policymakers at all levels of government will need to focus their attention on four closely related areas:

- expanding the amount and capability of technology in schools;
- providing training and support for teachers;
- encouraging innovation in educational software; and
- supporting research, development, demonstration, and evaluation, with emphasis on ties between research and the classroom.

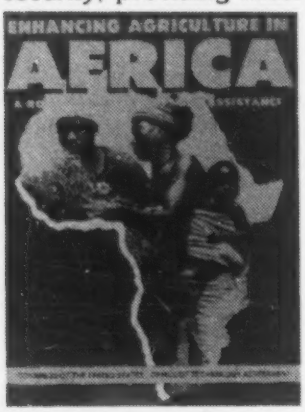
Effective Uses of Interactive Technology in Today's Classrooms

- Building basic skills through drills offering self-paced practice.
- Developing writing skills by facilitating the process of crafting ideas, revising structure, and fine-tuning one's work.
- Offering opportunities to develop strategies for problem solving.
- Providing new ways to understand abstract concepts in mathematics and science.
- Directing student discovery through simulations in science, mathematics, and social studies.
- Easing the collection, manipulation, and analysis of data for processing large amounts of information.

- Developing computer skills for general use and for business and vocational applications.
- Increasing access and communication opportunities for students with physical or other disabilities.
- Bringing teachers to schools in remote locations or to small groups of students wishing to study a subject not taught in their home school.
- Providing individualized instruction adjusted to each student's prior knowledge and rate and style of learning.
- Encouraging cooperative learning as students work together on computer projects in the classroom or on electronic networks across the continent.
- Easing some aspects of classroom management, such as recordkeeping, preparing instructional materials, and motivating students.

Enhancing Agriculture in Africa: A Role for U.S. Development Assistance

Africa's low-resource agriculturalists are the backbone of African food security, providing most of the region's food and employing most of its people. However, under the burgeoning demands of the world's fastest growing population, Africa's ability to feed itself continues to deteriorate, as does the natural resource base on which agriculture depends.



A growing consensus has emerged among the development assistance community that low-resource agriculture should be one focus of U.S. development assistance. This is based on the central, though largely neglected, role this type of agriculture already plays; the vast number of people already involved; the economic efficiency apparent on the small-farm sector in Africa; the significant capacity seen for technical improvements in current agricultural systems; and the likelihood that failing to increase support to this sector will mean continued deterioration of Africa's food security and accelerating degradation of its natural resource base.

"Low-resource agriculture" is based primarily on the use of local resources, but may also make modest use of external inputs, including information and technology. It is practiced by a diverse group of people. Women farmers in Malawi, for example, might grow a few hectares of maize, groundnuts, beans, tobacco, and vegetables, using some hybrid maize and fertilizer. Herders in the Sahel face harsher conditions with fewer outside resources. Their communities may move long distances in search of pasture and water, relying on animals for food, shelter, security, and status.

Improving low-resource agriculture can best be done by building off existing systems, rather than trying to replace them, and by merging the best

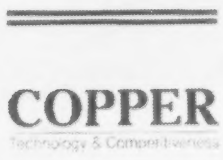
aspects of traditional systems with contributions of modern science. First, however, an improved understanding of low-resource agriculture must exist on which to base various approaches. Central elements of such a foundation will be environmental, institutional, technological, social, and economic sustainability; the role of risk, diversity, and flexibility in farming and herding systems; the many interactions within and among agricultural systems; and the best ways to use local resources, including local institutions.

As low-resource agriculture is enhanced, the vast majority of Africans will adopt more intensified, permanent production methods using more external and internal resources. This process is likely to be incremental. More rapid improvements are possible in high-potential areas but these areas are in a minority. A wide array of technologies will be needed to suit the myriad local conditions in Africa and to meet diverse and rapidly changing needs. These will include improved crop and animal genetics, better soil and water management, increased soil fertility, improved animal health, and reduced post-harvest losses.

One of the most enduring U.S. contributions to improving African food security is to promote Africans' abilities to adapt solutions already available within Africa and to borrow judiciously from abroad. Therefore, building African capability for agricultural research, education, and training is essential. This enlarged capability, along with expanded roles for local African organizations, can increase the relevance of development activities to local conditions and increase their cost-effectiveness and sustainability over the long term. These changes can best be carried out with stable, long-term funding, with more careful congressional oversight, and with substantial improvements in the Agency for International Development's priorities, operations, and philosophical approach.

Copper: Technology and Competitiveness

After facing hard times in the early 1980s, the domestic copper industry is now enjoying excellent profits. As a result of aggressive cost-cutting programs, the revitalized U.S. copper industry can now compete in all but the worst foreseeable markets. Notably, the industry's turnaround came entirely from its own efforts; the Federal Government rendered little direct assistance.



Earlier in this decade, the industry faced economic conditions that raised questions about its survival. Excess capacity and weak demand led to a prolonged period of low copper prices. Many U.S. mines and plants closed or cut back production as a result. From 1981 to 1986, domestic copper mine and refinery production each dropped 24 percent, and smelter output declined 31 percent. In contrast, U.S. copper consumption as a percent of world demand remained constant. Domestic import reliance grew from 6

percent in 1981 to 27 percent in 1986. Over 28,000 U.S. jobs were eliminated.

While U.S. output dropped, foreign production increased. In 1982—the year of the sharpest decline in the domestic industry—more than 60 percent of the copper-producing nations either increased or maintained their production levels.

During this period, U.S. copper companies sustained heavy financial losses and had to cut costs drastically. They closed high-cost operations. They modernized other facilities by installing larger, more efficient equipment and automated controls, both of which greatly increased productivity. Most operations also shifted some output from conventional mining and smelting to leaching mine wastes and processing the copper leachate by solvent extraction-electrowinning (SX-EW). This production method has low capital, labor, and operating costs (around 30 cents/lb).

Companies also reduced labor costs by around 20 percent in the 1986 contract negotiations, and renegotiated their electricity and transportation rates. Finally, they restructured through sales/purchases of copper or other business ventures.

These actions reduced the average U.S. net operating cost from a 1981 level of 80 to 90 cents/lb, to approximately 54 cents/lb in 1986. Costs in other major producing countries averaged around 45 cents/lb in that year.

These cost savings, combined with the recent unforeseen jump in prices, made all the major U.S. copper operations profitable in 1987. Today, the domestic industry is smaller, but it is still the world leader in smelter and refinery production, and ranks second in mine production.

Should the adverse conditions of the early 1980s recur, however, copper prices might fall to levels at which some domestic producers cannot compete. Higher cost operations would have the same three choices they did before: shut down, lose money, or find ways to cut costs further.

Most companies already have taken advantage of available technological cost-saving measures and reduced labor to a minimum. Thus they will have fewer means of cutting future costs without substantial R&D. Because technology transfer is almost instantaneous in the copper industry, the research most effective at giving a relative advantage to the United States will focus on resources or aspects of production that are common in the United States but rare elsewhere. Of ongoing research, the most promising is on methods to leach ore in place (i.e., without mining it). Cooperative research ventures involving producers, vendors, universities, and government agencies make the most efficient use of limited funds.

But technological innovation alone probably is insufficient to ensure survival of all domestic mines during another prolonged market slump. U.S. producers adjust output in response to price and demand; some of their foreign competitors are less sensitive to market signals and maintain full production in order to promote social goals such as employment and foreign exchange. This leads to copper surpluses when demand is weak, and would likely mean at least temporary cutbacks in the domestic industry regardless

of cost-saving innovations. To combat this trend, the Federal Government should continue active participation in the Copper Producer/Consumer Forum and the General Agreement on Tariffs and Trade (GATT) working group on nonferrous metals. Both provide forums for educating these countries about the adverse market effects of their production strategies during recessionary conditions.

The Federal Government also could consider options that would tend to equalize foreign and domestic production costs. These include reviewing U.S. contributions to international bank loans that provide subsidies for foreign copper projects; supporting general economic growth in less-developed countries (a higher standard of living would mean higher foreign wage rates); and promoting pollution control abroad. Also, the U.S.-Canada Free Trade Agreement phases out tariffs on Canadian copper (the source of 34 percent of U.S. imports during 1983-86), but fails to prohibit Canadian Government subsidies for mine and smelter modernizations.

Finally, government (and the industry) could actively promote domestic copper, whether through research on new products, through advertising, or through direct purchasing support (e.g., coinage, use of domestic materials in federally funded projects).

Gearing Up For Safety: Motor Carrier Safety in a Competitive Environment

Trucks are indispensable for transporting goods in the United States. They account for more than three of every four dollars spent on freight movement and 40 percent of intercity tonnage, a market share that has grown slowly, but steadily, since deregulation in 1980. Costs per ton-mile for the carrier industry have increased 75 percent since 1978, while rates charged to shippers have risen only 54 percent. Coupled with changes in operations and equipment, the resulting economic squeeze has major implications for highway safety.

Over the same time period, and unrelated to deregulation, highway traffic has increased steadily, worsening long-standing heavy vehicle safety problems. Traffic levels now exceed highway capacity in many urban areas; today's trucks are larger and heavier and travel more miles than those of 8 years ago, and much truck travel is on highways designed for automobiles. Although the number of fatalities in heavy vehicle accidents has held constant over the last 10 years, the number of accidents increased a total of 15 percent between 1981 and 1986, slightly more than the increase in heavy truck-miles. (This OTA report focuses primarily on heavy trucks, those with gross vehicle weights of over 26,000 pounds, because the category includes combination tractor-trailers—vehicles that pose the greatest driving challenges and the largest safety

hazards.) Four out of every five people killed in accidents involving truck tractor-trailer combinations are occupants of the other vehicle, usually a car.

Improving motor carrier safety requires a comprehensive and strategic approach, with action in three key areas:

- human performance, including training guidelines for drivers and maintenance personnel, studies of fatigue and hours of service, and management practices, such as hiring, scheduling, and drug and alcohol testing;
- technologies to improve safety in vehicle operations, including vehicle design and equipment requirements, such as tractor-trailer brake compatibility, antilock brakes, and vehicle visibility enhancements, as well as highway structure and design; and
- integrating governmental activities across all jurisdictional levels, to increase uniformity of regulations and enforcement, reduce burdens on industry, and improve carrier compliance.

Many governmental entities share responsibility for motor carrier safety, complicating industry operations and stymieing systematic efforts to resolve safety problems. At the Federal level, the Interstate Commerce Commission (ICC), and three U.S. Department of Transportation (DOT) agencies set standards and enforce different carrier regulations; these units do not work closely on safety issues. In Congress, a similar variety of committees share jurisdiction. Numerous State officials, such as Governors, State legislators, and Departments of Transportation, Highways, Police, and Public Safety, as well as regulatory bodies, also set requirements.

Federal safety legislation enacted since deregulation includes a major funding program (the Motor Carrier Safety Assistance Program—MCSAP) to boost States' enforcement capabilities, requirements for annual truck inspections and safety fitness ratings for all carriers, and requirements for a commercial vehicle driver's license. Although such legislation takes time to implement on a national scale, MCSAP has improved State programs dramatically, and the number of heavy truck accidents did drop slightly in 1986. Increased inspections have also caused record numbers of trucks and buses to be pulled out of service for violations.

Legislation passed in 1982 that increased taxes for heavy vehicles also authorized longer, wider vehicles, which now dominate intercity motor transport. Encouraged by potent industry lobbying, many States permit 53-foot trailers or even longer combination vehicles. However, many highways, such as the Interstate system, constructed with trucks in mind were built for considerably smaller vehicles than the combinations now standard. Reconstructing highways to increase width, passing lane length, sight distances, and ramp curves to accommodate these vehicles would be prohibitively expensive.

The three most common factors associated with heavy vehicle accidents are: 1) speed too fast for conditions; 2) driver's level of training; and 3) age of the vehicle. Human error causes over 60 percent of accidents, and appropriate training can increase a driver's skill and awareness of

appropriate speeds for roadway conditions. However, surveys tell us that many heavy-truck drivers never received any formal training, and no Federal training requirement is in place.

Truck operations often do not allow adequate rest for drivers, and researchers note significant increases in driving errors and decreases in driver alertness due to fatigue even within driving times well under the current hours-of-service limits. Recognizing the importance of such factors, some trucking companies have purchased new, fuel-efficient equipment, put in place training programs, and revised driver schedules to permit adequate rest. Many have seen their accident levels drop accordingly. However, independent drivers and companies that are strapped for cash often do not have the financial resources necessary for such safety investments.

A national program to improve motor carrier safety may bring somewhat higher direct transportation costs. These could be more than outweighed by a reduction in the societal costs of highway accidents, which recent estimates show will reach $65 billion by 1990.

SPECIAL REPORTS

Hospital Information Systems at the Veterans Administration

Focuses on the Decentralized Hospital Computer Program (DHCP) under development at the Veterans Administration. The report addresses near and long-term decisions that must be made concerning the direction of hospital information systems development at the VA, and provides a general review of the features and costs of DHCP and competing commercial hospital information systems.

Science, Technology, and the First Amendment

Addresses the issue of freedom of speech and press as they apply to scientific communications, and the extent to which these fundamental freedoms can be and are restricted in the interest of national security and export controls.

The Defense Technology Base: Introduction and Overview

Provides an overview of the defense technology base, including specific concerns about the health of the health of those industries, both defense-oriented and civilian, that provide the technology that winds up in defense systems, and on the management of the Defense Department's technology base programs and technology facilities.

Field-Testing Engineered Organisms: Genetic and Ecological Issues

Analyzes genetic and ecological issues raised by the deliberate release of genetically engineered organisms into the environment, and describes the present regulatory approach and relevant aspects of public opinion.

Criminal Justice, New Technologies, and the Constitution

Identifies new technologies used for investigation, apprehension, and confinement of offenders, and their effects on the constitutional protection of individual rights.

Are We Cleaning Up? 10 Superfund Case Studies

This special report presents 10 case studies of recent Superfund decisions based on surveying 100 recent cleanup decisions, that represents a broad range of contamination problems and cleanup technologies.

Paying the Bill: Manufacturing and America's Trade Deficit

This special report analyzes the causes of the deterioration in America's trade performance and examines the importance of U.S. manufacturing in helping the Nation improve its position in international trade.

U.S. Investment in Biotechnology

Describes the levels and types of investment currently being made by the Federal, State, and private sectors. The major issues identified that affect investment include: levels of R&D funding, research priorities, interagency coordination, information requirements, training and education needs, monitoring of university-industry research, State efforts to promote biotechnology, the effects of tax law on commercial biotechnology, the adequacy of Federal assistance for biotechnology start-ups, and the effects of export control on biotechnology commerce.

Launch Options for the Future: A Buyer's Guide

Describes the range of launch systems that exist or could be available before 2010 and explores the costs of meeting different demand levels for launching humans and spacecraft to orbit. The report also describes the importance of developing advanced technologies for space transportation.

Institutional Protocols for Decisions About Life-Sustaining Treatments

This special report focuses on the policies and guidelines by which health care institutions circumscribe and articulate the procedures they follow in making decisions whether to initiate, withhold, or withdraw life-sustaining treatments.

Biology, Medicine, and the Bill of Rights

Examines the implications of new developments in biological sciences for the freedoms and protections embedded in the Bill of Rights.

TECHNICAL MEMORANDA

Reducing Launch Operations Costs: New Technologies and Practices

Examines the launch process and how the use of advanced technologies and management techniques could reduce the costs of launching payloads and overall costs of space transportation.

BACKGROUND PAPERS

Identifying and Regulating Carcinogens

Describes policies issued by Federal agencies concerning the identification, assessment, and regulation of carcinogenic chemicals; the chemicals that have been regulated because of carcinogenic risk; the Federal Government's carcinogenicity testing program; and the results of OTA's analysis of the extent of agency action on chemicals determined to be carcinogenic.

Using Desalination Technologies for Water Treatment

Provides a technical assessment of traditional desalination techniques that can be used for water treatment.

Electronic Delivery of Public Assistance Benefits: Technology Options and Policy Issues

Discusses the technological options available for use in an electronic system to deliver public assistance benefits, the privacy and security implications of such a system, and the programmatic effects of changing to an electronic delivery system.

Artificial Insemination: Practice in the United States (Summary of a 1987 Survey)

Presents the results of a study of physician and sperm bank practice of artificial insemination in the United States. It documents the number of women undergoing artificial insemination each year, the annual cost, medical and social screening criteria for women seeking artificial insemination and men who donate semen, the genealogical recordkeeping available to resulting children, and physician attitudes toward possible changes in artificial insemination practice.

CASE STUDY

Neonatal Intensive Care for Low Birthweight Infants: Costs and Effectiveness

Analyzes evidence on the effectiveness of neonatal intensive care for the survival and normal developmental outcome of extremely premature babies.

STAFF PAPERS

AIDS and Health Insurance: An OTA Survey

Surveys commercial health insurers' underwriting practices for individual applicants for health insurance and on the impact of AIDS on their claims costs.

Urban Ozone and the Clean Air Act: Problems and Proposals for Change

Examines the ozone nonattainment problem. Issues discussed include: the effects of ozone, including discussions of the health effects of ozone, current exposure to ozone concentrations above the standard, and the effects of ozone on crops and trees; ways to control ozone, including analysis of the effects of emission reductions on ozone concentrations, the sources of the pollutants that lead to ozone formation, the likelihood of attaining the standard with reductions possible from existing control techniques, and the costs of controls; a history of efforts to control ozone since the Clean Air Act Amendments of 1970, focusing on the last major reauthorization in 1977, and why efforts since 1977 failed to bring more areas into attainment with the ozone standard; and a comparison of the three leading proposals addressing the ozone nonattainment problem.

How Effective Is AIDS Education?

Analyzes the effectiveness off educational efforts regarding the spread of infection with the AIDS virus.

Impact of AIDS on the Northern California Region of Kaiser Permanente

Reviews Kaiser Permanente Medical Care Program's northern California region's AIDS cases between 1981 and June 1987 and presents a cost analysis of a sample of these patients.

Section III.—Work in Progress

More than 25 projects were in progress during fiscal year 1988, in addition 20 new studies were undertaken.

This section lists the titles of assessments underway or in press, as of September 30, 1988. For a full description of these projects, please refer to the current "Assessment Activities," OTA-PC-105. This pamphlet may be obtained from OTA by calling OTA's Publication Request Line (202) 224-8996.

Energy, Materials, and International Security Division

Energy and Materials Program

- Copper: technology and competitiveness
- Technological risks and opportunities for future U.S. energy supply and demand
- Increased competition in the electric power industry
- High-temperature superconductors: research, development, and applications
- Oil production technologies in the Arctic National Wildlife Refuge

Industry, Technology, and Employment Program

- Technology, innovation, and U.S. trade
- Superfund implementation

International Security and Commerce Program

- Advanced space transportation technologies
- Maintaining the defense technology base
- Monitoring and preventing accidental radiation release at the Nevada test site

Health and Life Sciences Division

Biological Applications Program

- New developments in biotechnology
- Methods for locating and arranging health and long-term care for persons with dementia
- New developments in neuroscience
- Genetic testing in the workplace
- Forsenic uses of genetic tests
- Biotechnology in a global economy: options for U.S. strategy

Food and Renewable Resources Program

- Enhancing the quality of U.S. grain in international trade
- Grain quality in international trade: a comparison of major U.S. competitors
- Pesticide residues in food: technologies and methodologies for detection
- Agricultural approaches to reduce agrichemical contamination of groundwater in the United States
- U.S. universities and development assistance: technical support for agriculture, natural resources, and environment

Health Program

- Monitoring of mandated veterans studies (mandated study)
- Unconventional cancer treatments
- Drug labeling in developing and newly-industrialized countries
- Federal response to AIDS: congressional issues

Preventive health services under Medicare
Adolescent health
Rural health care

Science, Information, and Natural Resources Division

Communication and Information Technologies Program

Informing the Nation: Federal information dissemination in an electronic age
Communications systems for an information age
Science, technology, and the constitution in the information age
Copyright and home copying
Securities markets and information technology
Information technology and research

Oceans and Environment Program

New Clean Air Act issues
Municipal solid waste management
Managing low-level radioactive waste
Climate change: ozone depletion and the greenhouse effect
Potential for mineral resources development in antarctica and the convention of the regulation of antarctic mineral resource activities

Science, Education, and Transportation Program

Gearing up for safety: motor carrier safety in a competitive environment
Infrastructure technologies: rebuilding the foundations
Technologies for learning at a distance
High school vocational education: measures of program performance

Section IV.—Organization and Operations

Created by the Technology Assessment Act of 1972 [86 Stat. 797], OTA is an agency of the legislative branch of the Federal Government (a copy of the Act is found in app. C). OTA's primary function is to provide congressional committees with assessments or studies that identify the range of likely positive and negative consequences, social as well as physical, of policy alternatives affecting the uses of technology.

In providing assistance to Congress, OTA identifies: existing or probable impacts of technology or technological programs; alternative technological methods and management programs for implementing specific actions (estimating and comparing the impacts of alternatives); and areas where additional research or data collection is required to provide support for assessments. Finally, we present findings of completed analyses to the appropriate legislative authorities and, whenever possible, undertake such additional associated activities as may be necessary.

The Act provides for a bipartisan congressional board, a director, and such other employees and consultants as may be necessary to conduct the Office's work. The congressional board is made up of six Senators, appointed by the President pro tempore of the Senate, and six Representatives, appointed by the Speaker of the House, evenly divided by party. In 1988, Cong. Morris Udall (D-Arizona) and Sen. Ted Stevens (R-Alaska) served as the Chairman and Vice Chairman, respectively, of the board. The two posts alternate between the Senate and House with each Congress. The board members from each Chamber select their respective officer.

The congressional board sets the policies of the Office and is the sole and exclusive body governing OTA. The board appoints the director, who is OTA's chief executive officer and a nonvoting member of the board.

The Act also calls for a Technology Assessment Advisory Council composed of 10 public members eminent in scientific and technological fields, the Comptroller General of the United States, and the Director of the Congressional Research Service of the Library of Congress. The advisory council advises the board and the director on such matters as the balance, comprehensiveness, and quality of OTA's work, and OTA's nongovernmental resources.

Requests for OTA assessments may be initiated by:

- the chairman of any standing, special, select, or joint committee of Congress, acting alone, at the request of the ranking minority member, or at the request of a majority of the committee members;

- the OTA board; or
- the OTA Director, in consultation with the board.

The authorization of specific assessment projects and the allocation of funds for their performance are the responsibilities of the OTA Board.

The analytical work of the Office is organized into three divisions, each headed by an assistant director. They encompass assessments grouped in the areas of energy and materials; international security and commerce; industry, technology, and employment; biological applications; food and renewable resources; health; communication and information technologies; oceans and environment; and science, education, and transportation. (See chart detailing OTA's organizational structure.)

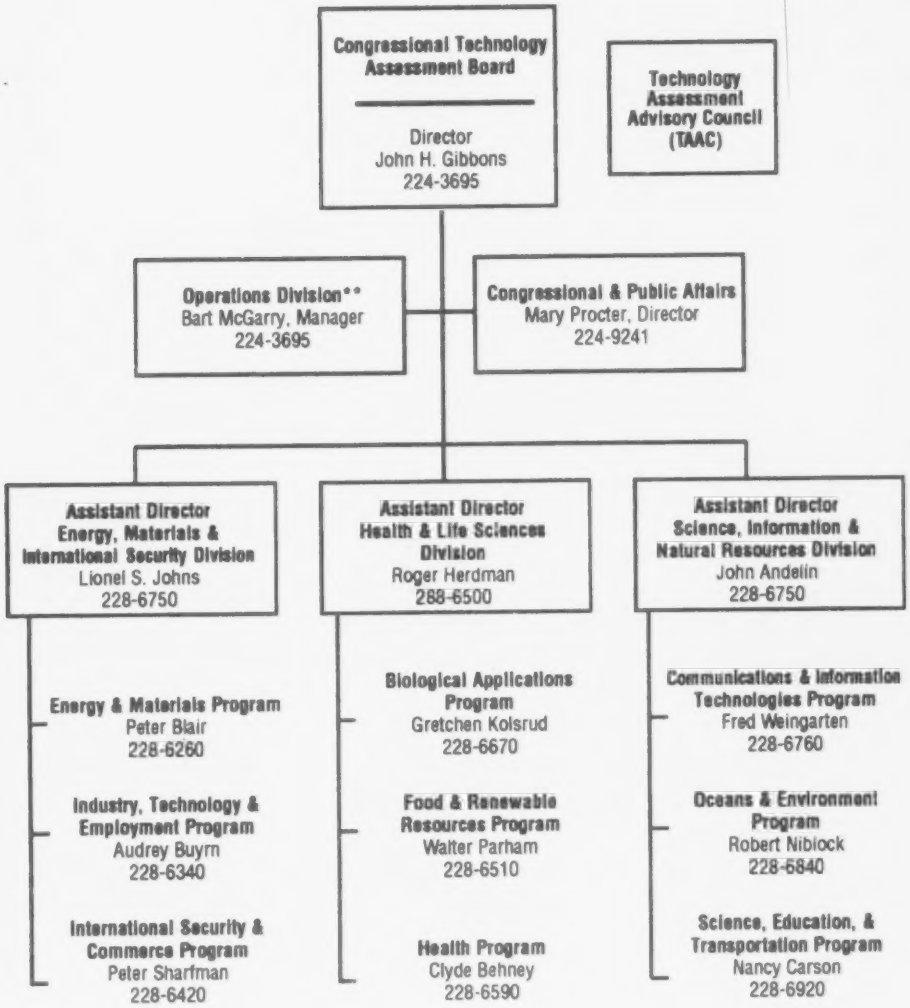
Staff of the Operations Division support the analytical work of the Office. These offices—Administrative Services, Contracts, Budget and Finance, Information Center, Personnel, Publishing, and Telecommunication and Information Systems—provide the research staff and management with a variety of services and technologies vital to successful functioning of the Office. The Congressional and Public Affairs Office staff play a critical role in the Office by assisting in coordinating OTA's work with various committees of House and Senate, providing effective communications between OTA management and staff and the Technology Assessment Board and Technology Assessment Advisory Council, and by assuring wide dissemination of OTA's publications on Capitol Hill, as well as to the general public.

Staff professionals represent a wide range of disciplines and backgrounds, including the physical, biological, and environmental sciences, engineering, social sciences, law, and public administration. Professionals from executive branch agencies, detailed to OTA on a temporary basis, and participants in several congressional fellowship programs also contribute to the work of the Office.

The private sector is heavily involved in OTA studies as a source of expertise and perspectives. Contractors and consultants are drawn from industry, universities, private research organizations, and public interest groups.

OTA works to ensure that the views of the public are fairly reflected in its assessments. OTA involves the public in many ways—through advisory panels, workshops, and formal and informal public meetings. These interactions provide citizens with access to information and help OTA to remain sensitive to the full array of perspectives, not only of the recognized stakeholders, but also of technically trained and lay persons.

OTA* ORGANIZATION CHART



*Located at 600 Pennsylvania Ave., S.E., Washington, DC.
- Publication request line—224-8996.
- Personnel locator—224-8713.

**Operations Division consists of the following units: Administrative Services, Budget and Finance, Information Center, Personnel Office, Publishing Office, and Telecommunications and Information Systems.

OPERATIONS

Publishing Activities

During fiscal 1988 OTA delivered 48 published documents to Congress. These included: 20 assessment reports, 11 special reports, 1 technical memorandum, 4 background papers, 1 case study, 4 staff papers, and 6 administrative reports.

Requests for OTA Publications

During the period September 30, 1987 through October 1, 1988, OTA's Publishing Office received an average of 76 telephone and mail requests per day. Additional requests were processed by OTA program offices and the OTA Congressional and Public Affairs Office and are not included in the above statistics.

Private Sector Reprinting of OTA Publications

OTA publications are often selected by commercial publishers or private organizations for reprinting. Among the publications reprinted during the fiscal year were:

- Princeton University Press [Princeton, NJ] reprinted:
  SDI: Technology, Survivability, and Software
- J.B. Lippincott Co. [Philadelphia, PA] reprinted:
  Life-Sustaining Technologies and the Elderly
- Lewis Publishers [Chelsea, MI] reprinted:
  Identifying and Regulating Carcinogens
- Marcel Dekker Publishing Co. [New York, NY] reprinted:
  Alternatives to Animal Use in Research, Testing, and Education
  Identifying and Regulating Carcinogens
- Technomic Publishing Co., Inc. [Lancaster, PA] reprinted:
  New Developments in Biotechnology: Field-Testing Engineered Organisms: Genetic and Ecological Issues
- Johns Hopkins University Press [Baltimore, MD] reprinted:
  Mapping Our Genes: Genome Projects—How Big, How Fast?
- Technical Association of the Pulp and Paper Industry [Atlanta, GA] reprinted:
  Summary: Book Preservation Technologies
- National Water Supply Improvement Association [St. Leonard, MD] reprinted:
  Using Desalination Technologies for Water Treatment

Sales of Publications

Government Printing Office.—Sales of OTA publications by the Superintendent of Documents continue to increase. In fiscal year 1988, the

cumulative number of titles on sale was 458 and a cumulative total of 41,486 copies sold

National Technical Information Service.—NTIS sells scientific reports and papers that are, generally, not in great demand but are useful for scientific researchers. NTIS is the outlet for OTA's assessment working papers and contractor reports, plus those reports that are out of print by GPO. During fiscal year 1988, NTIS sold 1,311 copies of OTA documents.

Organization Roster of OTA Staff as of September 1988

OFFICE OF THE DIRECTOR

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Sue Bachtel, *Executive Assistant*
Barbara Murphy, *Division Assistant*

Congressional and Public Affairs Office

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Jean McDonald, *Press Officer*
Ellen Mika, *Assistant Press Officer*
Karen Piccione, *Administrative Assistant*
Eugenia Ufholz, *Congressional Relations Officer*

Medical Services

Rose McNair, *Resident Nurse*

ENERGY, MATERIALS, AND INTERNATIONAL SECURITY DIVISION

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Beth Alexiou, *Division Assistant*

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Tina Brumfield, *Secretary*
Andrew Wyckoff, *Analyst*

Energy and Materials Program

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Alan Crane, *Senior Associate*
Joy Dunkerley, *Senior Analyst*
Gregory Eyring, *Senior Analyst*
Karen Larsen, *Senior Analyst*
Linda Long, *Administrative Secretary*
John Newman, *Analyst*
Steve Plotkin, *Senior Associate*
Jenifer Robison, *Senior Analyst*

Industry, Technology, and Employment Program

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Gregory van der Vink, *Senior Analyst*
Ray Williamson, *Senior Associate*

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Kerry Kemp, *Analyst*

Biological Applications Program

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Elaine Power, *Analyst*
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Bill Barnard, *Senior Analyst*
Kathleen Beil, *Administrative Assistant*
Rosina Bierbaum, *Senior Analyst*
James Curlin, *Senior Associate*
Robert Friedman, *Senior Associate*
Joan Harn, *Analyst*
Peter Johnson, *Senior Associate*
Howard Levenson, *Senior Analyst*
Gretchen McCabe, *Analyst*

Sally Van Aller, *Administrative Secretary*
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Kathleen Fulton, *Analyst*
Lisa Heinz, *Analyst*
Edith Page, *Senior Associate*
Linda Roberts, *Senior Analyst*

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Holly Gwin, *General Counsel*

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Claude Bowen, *Deputy Director of Contracts*

Operations Services

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Carolyn Harris, *Budget Assistant*
Frances Hemingway, *Assistant Finance Officer*
Carrie Miller, *Accounting Technician*

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Suzanne Boisclair, *Information Technician*
Leslie Fleming, *Information Technician*
Kathleen Flynn, *Information Technician*
Gail Kouril, *Assistant Manager, Information Services*

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Lola Craw, *Personnel Specialist*
Denise DeSanctis, *Personnel Specialist*
Elizabeth Millis, *Administrative Assistant*

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Kathie S. Boss, *Publishing Officer*
John Bergling, *Graphic Designer/Illustrator*
Debra Datcher, *Publishing Specialist*

Telecommunications and Information Services

Larry Bond, *Systems Analyst*
Phil Jackson, *Systems Analyst*
Brenda Miller, *Software Systems Specialist*

Appendixes

89-140 O - 89 - 3

Appendix A
Technology Assessment Advisory Council

The Technology Assessment Advisory Council (TAAC) was established by OTA's statute, and members are appointed by OTA's Congressional Technology Assessment Board (TAB). The Council advises TAB and the Director on issues and other matters related to science, technology, and technology assessment.

Members of TAAC on September 30, 1988, were:

William J. Perry, *Chairman:* Dr. Perry is managing partner of H&Q Technology Partners. In 1985 he was a managing director in the investment banking firm of Hambrecht & Quist, Inc. Prior to joining H&Q, he was the U.S. Under Secretary of Defense for Research and Engineering. He is a member of the National Academy of Engineering.

David S. Potter, *Vice Chairman:* Dr. Potter retired as Vice President, Power Products and Defense Operations Group at General Motors in June 1985. He was formerly Assistant Secretary of the Navy for Research and Development and Under Secretary of the Navy. He is a member of the National Academy of Engineering.

Earl Beistline: Dr. Beistline is a private consultant in Fairbanks, Alaska. He is former Dean of the School of Mineral Industry, and also Former Provost of the University of Alaska.

S. David Freeman: Mr. Freeman is the General Manager of the Lower Colorado River Authority. He is former Chairman and member of the Board of the Tennessee Valley Authority. He has headed the energy policy staff of the President's Office of Science and Technology Policy; directed the Ford Foundation Energy Policy Project; and served as assistant to the Chairman of the Federal Power Commission.

Michel T. Halbouty: Mr. Halbouty is Chairman of the Board of Michel T. Halbouty Energy Co. in Houston, Texas. Prior to establishing his company, he was a chief geologist and petroleum engineer with Glenn H. McCarthy and also with Yount-Lee Oil Co.

Neil Harl: Dr. Harl is the Charles F. Curtiss Distinguished Professor of Economics at Iowa State University, where he has served on the faculty since 1964.

James C. Hunt: Dr. Hunt is the chancellor of the University of Tennessee Health Science Center in Memphis. He previously served as the Dean of Medicine for the University and as Chairman of the Department of Medicine at the Mayo Clinic.

Joshua Lederberg: Dr. Lederberg is the President of Rockefeller University. He is the former Chairman of the Department of Genetics at

Stanford University School of Medicine. He is a Member of the National Academy of Sciences and is a Nobel Laureate in Physiology and Medicine.

Chase N. Peterson: Dr. Peterson is President of the University of Utah. He practiced medicine at the Salt Lake Clinic and taught at the LDS Hospital and University of Utah Medical School until his appointment as Dean of Admissions and Financial Aids at Harvard College. There he also served as Vice President for Alumni Affairs and Development. Dr. Peterson returned to the University of Utah in 1978 as Vice President for Health Sciences, and has served as University President since 1983.

Sally Ride: Dr. Ride is currently a fellow at the Stanford University Center for International Security and Arms Control. She is a former astronaut, and served as a member of the Presidential Commission on the Space Shuttle.

Statutory Members

Charles A. Bowsher: Mr. Bowsher is Comptroller General of the United States and Director of the U.S. General Accounting Office.

Joseph E. Ross: Mr. Ross is Director of the Congressional Research Service, U.S. Library of Congress.

Appendix B
List of Advisors and Panel Members*

ENERGY, MATERIALS, AND INTERNATIONAL SECURITY DIVISION

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Vice President
Citibank

Mary Jo Manning, Esq.
Partner
Willkes, Artis, Hedrick & Lane

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Howard Young
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Energy and Materials Program

ANWR Technologies Workshop

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Defending Secrets, Sharing Data: New Locks & Keys for Electronic Information Advisory Panel

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U.S. Environmental Protection Agency

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Appendix C
OTA Act

Public Law 92-484
92nd Congress, H. R. 10243
October 13, 1972

An Act

86 STAT. 797

To establish an Office of Technology Assessment for the Congress as an aid in the identification and consideration of existing and probable impacts of technological application; to amend the National Science Foundation Act of 1950; and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Technology Assessment Act of 1972".

Technology Assessment Act of 1972.

FINDINGS AND DECLARATION OF PURPOSE

SEC. 2. The Congress hereby finds and declares that:

(a) As technology continues to change and expand rapidly, its applications are—

(1) large and growing in scale; and

(2) increasingly extensive, pervasive, and critical in their impact, beneficial and adverse, on the natural and social environment.

(b) Therefore, it is essential that, to the fullest extent possible, the consequences of technological applications be anticipated, understood, and considered in determination of public policy on existing and emerging national problems.

(c) The Congress further finds that:

(1) the Federal agencies presently responsible directly to the Congress are not designed to provide the legislative branch with adequate and timely information, independently developed, relating to the potential impact of technological applications, and

(2) the present mechanisms of the Congress do not and are not designed to provide the legislative branch with such information.

(d) Accordingly, it is necessary for the Congress to—

(1) equip itself with new and effective means for securing competent, unbiased information concerning the physical, biological, economic, social, and political effects of such applications; and

(2) utilize this information, whenever appropriate, as one factor in the legislative assessment of matters pending before the Congress, particularly in those instances where the Federal Government may be called upon to consider support for, or management or regulation of, technological applications.

ESTABLISHMENT OF THE OFFICE OF TECHNOLOGY ASSESSMENT

SEC. 3. (a) In accordance with the findings and declaration of purpose in section 2, there is hereby created the Office of Technology Assessment (hereinafter referred to as the "Office") which shall be within and responsible to the legislative branch of the Government.

(b) The Office shall consist of a Technology Assessment Board (hereinafter referred to as the "Board") which shall formulate and promulgate the policies of the Office, and a Director who shall carry out such policies and administer the operations of the Office.

Technology Assessment Board.

(c) The basic function of the Office shall be to provide early indications of the probable beneficial and adverse impacts of the applications of technology and to develop other coordinate information which may assist the Congress. In carrying out such function, the Office shall:

Duties.

(1) identify existing or probable impacts of technology or technological programs;

86 STAT. 798

(2) where possible, ascertain cause-and-effect relationships;
(3) identify alternative technological methods of implementing specific programs;
(4) identify alternative programs for achieving requisite goals;
(5) make estimates and comparisons of the impacts of alternative methods and programs;
(6) present findings of completed analyses to the appropriate legislative authorities;
(7) identify areas where additional research or data collection is required to provide adequate support for the assessments and estimates described in paragraph (1) through (5) of this subsection; and
(8) undertake such additional associated activities as the appropriate authorities specified under subsection (d) may direct.

(d) Assessment activities undertaken by the Office may be initiated upon the request of:
(1) the chairman of any standing, special, or select committee of either House of the Congress, or of any joint committee of the Congress, acting for himself or at the request of the ranking minority member or a majority of the committee members;
(2) the Board; or
(3) the Director, in consultation with the Board.

Information, availability.

(e) Assessments made by the Office, including information, surveys, studies, reports, and findings related thereto, shall be made available to the initiating committee or other appropriate committees of the Congress. In addition, any such information, surveys, studies, reports, and findings produced by the Office may be made available to the public except where—
(1) to do so would violate security statutes; or
(2) the Board considers it necessary or advisable to withhold such information in accordance with one or more of the numbered paragraphs in section 552(b) of title 5, United States Code.

81 Stat. 54.

TECHNOLOGY ASSESSMENT BOARD

Membership.

SEC. 4. (a) The Board shall consist of thirteen members as follows:
(1) six Members of the Senate, appointed by the President pro tempore of the Senate, three from the majority party and three from the minority party;
(2) six Members of the House of Representatives appointed by the Speaker of the House of Representatives, three from the majority party and three from the minority party; and
(3) the Director, who shall not be a voting member.

Vacancies.

(b) Vacancies in the membership of the Board shall not affect the power of the remaining members to execute the functions of the Board and shall be filled in the same manner as in the case of the original appointment.

Chairman and vice chairman.

(c) The Board shall select a chairman and a vice chairman from among its members at the beginning of each Congress. The vice chairman shall act in the place and stead of the chairman in the absence of the chairman. The chairmanship and the vice chairmanship shall alternate between the Senate and the House of Representatives with each Congress. The chairman during each even-numbered Congress shall be selected by the Members of the House of Representatives on the Board from among their number. The vice chairman during each

Congress shall be chosen in the same manner from that House of Congress other than the House of Congress of which the chairman is a Member.

(d) The Board is authorized to sit and act at such places and times during the sessions, recesses, and adjourned periods of Congress, and upon a vote of a majority of its members, to require by subpena or otherwise the attendance of such witnesses and the production of such books, papers, and documents, to administer such oaths and affirmations, to take such testimony, to procure such printing and binding, and to make such expenditures, as it deems advisable. The Board may make such rules respecting its organization and procedures as it deems necessary, except that no recommendation shall be reported from the Board unless a majority of the Board assent. Subpenas may be issued over the signature of the chairman of the Board or of any voting member designated by him or by the Board, and may be served by such person or persons as may be designated by such chairman or member. The chairman of the Board or any voting member thereof may administer oaths or affirmations to witnesses.

Meetings.

Subpena.

DIRECTOR AND DEPUTY DIRECTOR

SEC. 5. (a) The Director of the Office of Technology Assessment shall be appointed by the Board and shall serve for a term of six years unless sooner removed by the Board. He shall receive basic pay at the rate provided for level III of the Executive Schedule under section 5314 of title 5, United States Code.

Appointment.

Compensation.

83 Stat. 863.

(b) In addition to the powers and duties vested in him by this Act, the Director shall exercise such powers and duties as may be delegated to him by the Board.

(c) The Director may appoint with the approval of the Board, a Deputy Director who shall perform such functions as the Director may prescribe and who shall be Acting Director during the absence or incapacity of the Director or in the event of a vacancy in the office of Director. The Deputy Director shall receive basic pay at the rate provided for level IV of the Executive Schedule under section 5315 of title 5, United States Code.

(d) Neither the Director nor the Deputy Director shall engage in any other business, vocation, or employment than that of serving as such Director or Deputy Director, as the case may be; nor shall the Director or Deputy Director, except with the approval of the Board, hold any office in, or act in any capacity for, any organization, agency, or institution with which the Office makes any contract or other arrangement under this Act.

Employment restriction.

AUTHORITY OF THE OFFICE

SEC. 6. (a) The Office shall have the authority, within the limits of available appropriations, to do all things necessary to carry out the provisions of this Act, including, but without being limited to, the authority to—

(1) make full use of competent personnel and organizations outside the Office, public or private, and form special ad hoc task forces or make other arrangements when appropriate;

(2) enter into contracts or other arrangements as may be necessary for the conduct of the work of the Office with any agency or instrumentality of the United States, with any State, territory,

Contracts.

86 STAT. 800

or possession or any political subdivision thereof, or with any person, firm, association, corporation, or educational institution, with or without reimbursement, without performance or other bonds, and without regard to section 3709 of the Revised Statutes (41 U.S.C. 5);

(3) make advance, progress, and other payments which relate to technology assessment without regard to the provisions of section 3648 of the Revised Statutes (31 U.S.C. 529);

(4) accept and utilize the services of voluntary and uncompensated personnel necessary for the conduct of the work of the Office and provide transportation and subsistence as authorized by section 5703 of title 5, United States Code, for persons serving without compensation;

80 Stat. 499; 83 Stat. 190.

(5) acquire by purchase, lease, loan, or gift, and hold and dispose of by sale, lease, or loan, real and personal property of all kinds necessary for or resulting from the exercise of authority granted by this Act; and

(6) prescribe such rules and regulations as it deems necessary governing the operation and organization of the Office.

Recordkeeping.

(b) Contractors and other parties entering into contracts and other arrangements under this section which involve costs to the Government shall maintain such books and related records as will facilitate an effective audit in such detail and in such manner as shall be prescribed by the Office, and such books and records (and related documents and papers) shall be available to the Office and the Comptroller General of the United States, or any of their duly authorized representatives, for the purpose of audit and examination.

(c) The Office, in carrying out the provisions of this Act, shall not, itself, operate any laboratories, pilot plants, or test facilities.

Agency cooperation.

(d) The Office is authorized to secure directly from any executive department or agency information, suggestions, estimates, statistics, and technical assistance for the purpose of carrying out its functions under this Act. Each such executive department or agency shall furnish the information, suggestions, estimates, statistics, and technical assistance directly to the Office upon its request.

Personnel detail.

(e) On request of the Office, the head of any executive department or agency may detail, with or without reimbursement, any of its personnel to assist the Office in carrying out its functions under this Act.

(f) The Director shall, in accordance with such policies as the Board shall prescribe, appoint and fix the compensation of such personnel as may be necessary to carry out the provisions of this Act.

ESTABLISHMENT OF THE TECHNOLOGY ASSESSMENT ADVISORY COUNCIL

Membership.

SEC. 7. (a) The Office shall establish a Technology Assessment Advisory Council (hereinafter referred to as the "Council"). The Council shall be composed of the following twelve members:

(1) ten members from the public, to be appointed by the Board, who shall be persons eminent in one or more fields of the physical, biological, or social sciences or engineering or experienced in the administration of technological activities, or who may be judged qualified on the basis of contributions made to educational or public activities;

(2) the Comptroller General; and

(3) the Director of the Congressional Research Service of the Library of Congress.

(b) The Council, upon request by the Board, shall— Duties.

(1) review and make recommendations to the Board on activities undertaken by the Office or on the initiation thereof in accordance with section 3(d);

(2) review and make recommendations to the Board on the findings of any assessment made by or for the Office; and

(3) undertake such additional related tasks as the Board may direct.

(c) The Council, by majority vote, shall elect from its members appointed under subsection (a)(1) of this section a Chairman and a Vice Chairman, who shall serve for such time and under such conditions as the Council may prescribe. In the absence of the Chairman, or in the event of his incapacity, the Vice Chairman shall act as Chairman. Chairman and Vice Chairman.

(d) The term of office of each member of the Council appointed under subsection (a)(1) shall be four years except that any such member appointed to fill a vacancy occurring prior to the expiration of the term for which his predecessor was appointed shall be appointed for the remainder of such term. No person shall be appointed a member of the Council under subsection (a)(1) more than twice. Terms of the members appointed under subsection (a)(1) shall be staggered so as to establish a rotating membership according to such method as the Board may devise. Term of office.

(e)(1) The members of the Council other than those appointed under subsection (a)(1) shall receive no pay for their services as members of the Council, but shall be allowed necessary travel expenses (or, in the alternative, mileage for use of privately owned vehicles and a per diem in lieu of subsistence at not to exceed the rate prescribed in sections 5702 and 5704 of title 5, United States Code), and other necessary expenses incurred by them in the performance of duties vested in the Council, without regard to the provisions of subchapter 1 of chapter 57 and section 5731 of title 5, United States Code, and regulations promulgated thereunder. Travel expenses. 80 Stat. 498; 83 Stat. 190. 5 USC 5701.

(2) The members of the Council appointed under subsection (a)(1) shall receive compensation for each day engaged in the actual performance of duties vested in the Council at rates of pay not in excess of the daily equivalent of the highest rate of basic pay set forth in the General Schedule of section 5332(a) of title 5, United States Code, and in addition shall be reimbursed for travel, subsistence, and other necessary expenses in the manner provided for other members of the Council under paragraph (1) of this subsection. Compensation.

UTILIZATION OF THE LIBRARY OF CONGRESS

SEC. 8. (a) To carry out the objectives of this Act, the Librarian of Congress is authorized to make available to the Office such services and assistance of the Congressional Research Service as may be appropriate and feasible.

(b) Such services and assistance made available to the Office shall include, but not be limited to, all of the services and assistance which the Congressional Research Service is otherwise authorized to provide to the Congress.

(c) Nothing in this section shall alter or modify any services or responsibilities, other than those performed for the Office, which the Congressional Research Service under law performs for or on behalf

of the Congress. The Librarian is, however, authorized to establish within the Congressional Research Service such additional divisions, groups, or other organizational entities as may be necessary to carry out the purpose of this Act.

(d) Services and assistance made available to the Office by the Congressional Research Service in accordance with this section may be provided with or without reimbursement from funds of the Office, as agreed upon by the Board and the Librarian of Congress.

UTILIZATION OF THE GENERAL ACCOUNTING OFFICE

SEC. 9. (a) Financial and administrative services (including those related to budgeting, accounting, financial reporting, personnel, and procurement) and such other services as may be appropriate shall be provided the Office by the General Accounting Office.

(b) Such services and assistance to the Office shall include, but not be limited to, all of the services and assistance which the General Accounting Office is otherwise authorized to provide to the Congress.

(c) Nothing in this section shall alter or modify any services or responsibilities, other than those performed for the Office, which the General Accounting Office under law performs for or on behalf of the Congress.

(d) Services and assistance made available to the Office by the General Accounting Office in accordance with this section may be provided with or without reimbursement from funds of the Office, as agreed upon by the Board and the Comptroller General.

COORDINATION WITH THE NATIONAL SCIENCE FOUNDATION

SEC. 10. (a) The Office shall maintain a continuing liaison with the National Science Foundation with respect to—

(1) grants and contracts formulated or activated by the Foundation which are for purposes of technology assessment; and

(2) the promotion of coordination in areas of technology assessment, and the avoidance of unnecessary duplication or overlapping of research activities in the development of technology assessment techniques and programs.

Scientific programs, financing. 92 Stat. 360.

(b) Section 3(b) of the National Science Foundation Act of 1950, as amended (42 U.S.C. 1862(b)), is amended to read as follows:

"(b) The Foundation is authorized to initiate and support specific scientific activities in connection with matters relating to international cooperation, national security, and the effects of scientific applications upon society by making contracts or other arrangements (including grants, loans, and other forms of assistance) for the conduct of such activities. When initiated or supported pursuant to requests made by any other Federal department or agency, including the Office of Technology Assessment, such activities shall be financed whenever feasible from funds transferred to the Foundation by the requesting official as provided in section 14(g), and any such activities shall be unclassified and shall be identified by the Foundation as being undertaken at the request of the appropriate official."

64 Stat. 156; 82 Stat. 365. 42 USC 1873.

ANNUAL REPORT

SEC. 11. The Office shall submit to the Congress an annual report which shall include, but not be limited to, an evaluation of technology assessment techniques and identification, insofar as may be feasible, of technological areas and programs requiring future analysis. Such report shall be submitted not later than March 15 of each year.

APPROPRIATIONS

SEC. 12. (a) To enable the Office to carry out its powers and duties, there is hereby authorized to be appropriated to the Office, out of any money in the Treasury not otherwise appropriated, not to exceed $5,000,000 in the aggregate for the two fiscal years ending June 30, 1973, and June 30, 1974, and thereafter such sums as may be necessary.

(b) Appropriations made pursuant to the authority provided in subsection (a) shall remain available for obligation, for expenditure, or for obligation and expenditure for such period or periods as may be specified in the Act making such appropriations.

Approved October 13, 1972.

LEGISLATIVE HISTORY:

HOUSE REPORTS: No. 92-469 (Comm. on Science and Astronautics) and No. 92-1436 (Comm. of Conference).
SENATE REPORT No. 92-1123 (Comm. on Rules and Administration).
CONGRESSIONAL RECORD, Vol. 118 (1972):
Feb. 8, considered and passed House.
Sept.14, considered and passed Senate, amended.
Sept.22, Senate agreed to conference report.
Oct. 4, House agreed to conference report.

OTA-A-411

[redacted]